# كشف الأسرار عن كركرةِ الأحبار في تأويل الأدوار

# KASHF AL-ASRĀR ʿAN KARKARAT AL-AḤBĀR FĪ TAʾWĪL AL-ADWĀR[1]

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### "*In guise of introduction*"[2]

The reason behind this article is such that I feel compelled to write it down as an introduction.

As I was researching the first issue of my book on the theory and practice of Arabian music [Beyhom, 2010c], I was amazed at certain texts which were either written in the form of *urjūzāt*[3] or attempted at explaining the unexplainable as if it were common truth. I reacted in an Occidental manner expecting rationalism in an irrational planet. However, I was not alone in my wonderings, as my parallel research on the Indian musical scale was gradually showing that there was no satisfactory explanation to the phenomenon of the well-known 22 *śrutis*[4] to an octave.

Having spent years studying various forms of octave divisions[5] as well as meticulous analyses of specific scores,[6] I found myself on the way of solving, gradually, a good deal of Arabian music riddles which had always intrigued me. At the same time, I was struggling with my understanding of the *śruti* for the reason that early Indian treatises are written in Sanskrit, a language which is obscure to me. Neither could I understand commentators[7] and read the treatises in their original languages and attempt at understanding if previous researchers did not wear blinkers[8] comparable to the ones of their counterparts for Arabian music.[9]

These approaches of a wide panel of music theories, combined with a critical point of view on previous Pythagorean-biased and nationalist-influenced[10] studies allow me, at present, to make two hypotheses for riddle solving, characteristic of modal musicology.

## THE 28 "QUARTERTONES" OF SHIHĀB-A-D-DĪN (19th CENTURY)

A poet and scholar,[11] *Shaykh*[12] Shihāb-a-d-Dīn Muḥammad ibn Ismāʿīl ibn ʿUmar al-Makkī al-Ḥijāzī[13] studied at (al-) Azhar university in Cairo. In a treatise published in 1864,[14] *Safīnat al-Mulk wa-Nafīsat al-Fulk*, Shihāb-a-d-Dīn describes a division of the octave in 28 "quarters". This division attracted many musicological considerations, most of them inspired by Scott Marcus' opinion that the Sheikh did not really understand the music he described[15]. At least one Egyptian musicologist, on the other hand, tends to agree that the Sheikh was "the real inventor of the 24-quartertones scale",[16] and denies the fact that the latter division seemed to be already present in the Middle-East at the time: the Lebanese Mīkhā'īl Mashāqa tells us that he had heard from it in about 1820, in Damascus, from Sheikh al-ʿAṭṭār.[17]

We will attempt at showing, in the next sections, that Shihāb-a-d-Dīn's division is probably a continuation of previous attempts with the Arabian scale, and that his thoughts may have shifted towards a *practical* way of explaining the music he wrote about.

### *Shihāb-a-d-Dīn's explanations of the "quarters"*

As a first observation of Shihāb-a-d-Dīn's scale, it is possible to say, indubitably, that the Sheikh attests of 28 "quarters"[18] in his treatise.

In his *Safīnat al-Mulk* the author explicitly counts 28 *maqāmāt* which are differentiated pitches within the octave, as shown from the lithographic version (Fig. 1):

> "and the number of *maqāmāt* is twenty-eight, divided into *uṣūl* and *furūʿ*; as for the *uṣūl*, their number is seven only, and they hold names ordered in ascension [...] and the first is *Y[Ā]KĀ*[19] and the second *DŪKĀ* and the third *DŪKĀ* [*sic.* See endnote and Figure 2][20] and the fourth [p. 12] *JAHĀRKĀ* [or *JHĀRKĀ* or *GAHĀRKĀH*, etc.] and the fifth *BANJKĀ* [other possible transliterations] and the sixth *SHĀSHKĀ* and the seventh *HAFTKĀ* [… p. 13] concerning the *furūʿ*, their number is twenty-one and they are divided in three [types] into *ʿarabāt*, *nīmāt* of *ʿarabāt* and *tīkāt* of *ʿarabāt* according to the distance [« the interval »[21]] between the degrees, and the proof of this is that the interval [*al-buʿd*] comprised between two *uṣūl* of the seven cited can be complete and is called a *burda*, and can be [… p. 14] incomplete and is called a *ʿaraba* or a *nīm* of *ʿaraba*; because if you emit a sound beginning with one of the seven *uṣūl* and move on [upwards] you cross either the distance of the interval between [the *aṣl*] and the following degree, and you stop there [on it], or you cross [only] half, or a quarter or three-quarters of the distance, and you halt there. By crossing the complete distance and stopping there, you stop on the *burda*, and the interval [*buʿd*] is complete; by crossing half the distance and stopping there, you are on the *ʿaraba*, and if you cross a quarter

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only, you stop on the *nīm* of the *ʿaraba* which is its half, and the half of the half is the quarter; by crossing three-quarters of the distance, you stop on the *tīk* of the *ʿaraba* and the distance [*buʿd*] will be incomplete. In this, the consequence is that the number of the *ʿarabāt* is seven, as well as the number of the *nīmāt* and of the *tīkāt*, and that each of the seven *ʿarabāt* is between two of the degrees of the *uṣūl*."[22]


باسم مخصوص وان عدة للمقامات ثمانية وعشرون مقاما وهي تنقسم
الى اصول وفروع اما الاصول فعدتها سبعة فقط وهي مسماة باسماء
مرتبة بعضها فوق بعض بالترقي درجة فدرجة حسب مراتب العدد
المسرود على التوالي اولها يكاه وثانيها دوكاه وثالثها دوكاه ورابعها

جهاركاه وخامسها بنجكاه وسادسها ششكاه وسابعها هفتكاه

على ما ذكر فتنبه ولا تكن من الغافلين واما الفروع فعدتها
احد وعشرون فرعا وهي تنقسم بالقسمة الثلاثية الى عربات
ونيمات عربات وتيكات عربات نظرا الى مقادير مسافة البعد
فيما بين الدرجات وبيان هذا ان مسافة البعد الواقعة فيما بين كل
اصلين من السبعة المتقدمة قد تكون كاملة وتسمى بردة وقد تكون

ناقصة وتسمى عربة او نيم عربة فاذا رفعت صوتك مبتدئا بدرجة
من الدرجات السبع التي هي الاصول وانتقلت منها فاما ان تقطع
مسافة البعد التي بينها وبين الدرجة التي تليها وتنتهي اليها واما ان
تقطع نصف المسافة او ربعها او ثلاثة ارباعها فقط وتقف ثمة
فان انت قطعتها باجمعها وانتهيت الى الدرجة كنت واقفا على البردة
وكانت مسافة البعد كاملة وان قطعت نصفها ووقفت كنت واقفا
على العربة او ربعها فقط كنت واقفا على نيم العربة اى نصفها ونصف
النصف ربع او ثلاثة ارباعها كنت واقفا على تيك العربة وكانت المسافة
على كل ناقصة وبهذا تبين ان عدة العربات سبع وكذا عدة كل من النيمات والتيكات
ضرورة وان كل واحدة من العربات السبع واقعة بين درجتين من
درجات الاصول وينبني على هذا ان يكون ترتيبها كترتيب الاصول

Fig. 1.1 to 1.4 Excerpts from pages 11, 12, 13 and 14 of the lithographic edition of Shihāb-a-d-Dīn's *Safīnat al-Mulk wa Nafīsat al-Fulk* explaining the process of division of the octave in 28 *maqāmāt*.[23]

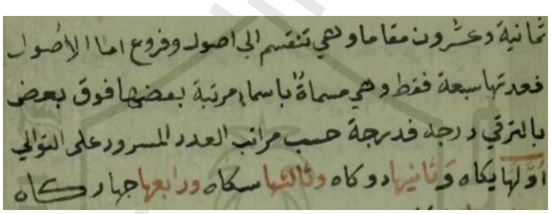

ثمانية وعشرون مقاما وهي تنقسم الى اصول وفروع اما الاصول
فعدتها سبعة فقط وهي مسماة باسماء مرتبة بعضها فوق بعض
بالترقي درجة فدرجة حسب مراتب العدد المسرود على التوالي
اولها يكاه وثانيها دوكاه وثالثها سيكاه ورابعها جهاركاه

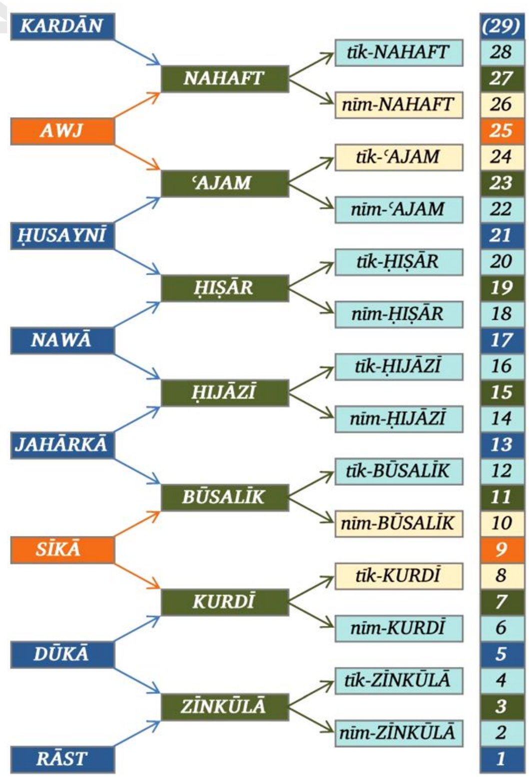
Fig. 2. Excerpt from the Ms. *z* 2935[24] matching our excerpt (Fig. 1.1) from page 11 of *li* 1864 above: the third degree (*aṣl*) is clearly here *SĪKĀ*, and not *DŪKĀ* as written in the lithographic copy.

Shihāb-a-d-Dīn also explains [1864, p. 14–15] how the names of the main degrees of the scale evolved and became the ones shown in Figure 3.[25]

| | | | |
|---|---|---|---|
| *KARDĀN* | ↔ | *rā* $_2$ | *c'* |
| *AWJ* | ↔ | *aw* $_2$ | *b* $^{hf}$ |
| *ḤUSAYNĪ* | ↔ | *ḥu* $_2$ | *a* |
| *NAWĀ* | ↔ | *na* $_2$ | *g* |
| *JAHĀRKĀ* | ↔ | *ja* | *f* |
| *SĪKĀ* | ↔ | *sī* | *e* $^{hf}$ |
| *DŪKĀ* | ↔ | *dū* | *d* |
| *RĀST* | ↔ | *rā* | *c* |

Fig. 3. Modern names of the main scale degrees of Arabian music[26] (left) and proposed solmisation (2nd column from the right); corresponding Western pitches are shown in the column to the right.[27]

The author mentions the names of the seven *ʿarabāt*, which are *ZĪNKŪLĀ*, *KURDĪ*, *BŪSALĪK*,[28] *ḤIJĀZĪ*, *ḤIṢĀR*, *ʿAJAM*[29] and *NAHAFT*.[30] Adding to them the *tīkāt* and *nīmāt*, which are alterations of the *ʿarabāt* in the upper or the lower direction, we have the 28 "*maqāmāt*" of *Shihāb-a-d-Dīn* (Fig. 4).




***7 burdāt + 7 ʿarabāt + 7 tīkāt + 7 nīmāt = 28 "quarters"***

Fig. 4. The "*maqāmāt*" of Shihāb-a-d-Dīn divided into *burdāt, ʿarabāt, tīkāt* and *nīmāt*.[31]

However, this contradicts the Modern Arabian theory of the "quarters", since 24 quartertones in an octave can *not* sum up to 28 "quarters", unless the "quarters" are *not* equivalent to "quartertones".[32]

As a conclusion to this point, let us note that Caron and Safvate (among others), in their retrospective study of the music of Iran,[33] underline that *Shihāb-a-d-Dīn's* division corresponds to the division of the seven main intervals of the Arabian scale, commonly stated in modern literature as composed of one-tone and three-quartertones intervals, in further halves and quarters of "tone", regardless of the values of the "tone"[34] (Fig. 5).[35]

| *rāst* | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *rā* | 4 | *dū* | 3 | *sī* | 3 | *ja* | 4 | *na* $_2$ | 4 | *ḥu* $_2$ | 3 | *aw* $_2$ | 3 | *rā* $_2$ |
| *c* | 4 | *d* | 3 | $e^{hf}$ | 3 | *f* | 4 | *g* | 4 | *a* | 3 | $b^{hf}$ | 3 | *c'* |
| | | | | | | | | *rāst* | | | | | | |

Fig. 5. Modern division of the octave of Arabian music in quartertones and two ascending *rāst* tetrachords ($c\ d\ e^{hf} f$ and $g\ a\ b^{hf}$ c' $g$ – "hf" stands for "half-flat") joined by a "disjunction" tone (*f g*).

## *The way to 28*

Nowadays, the basic scale of Arabian music is usually given as a two-octave scale composed of one-tone and three-quartertones intervals (Fig. 6).

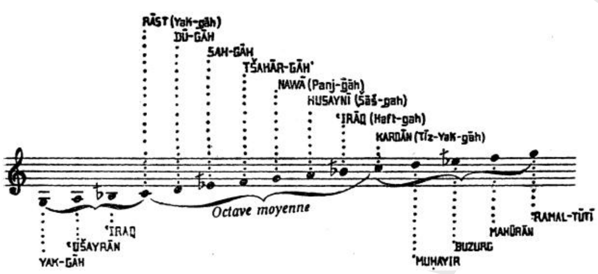



Fig. 6. Basic scale of the Arabian music according to Erlanger[36]: ɓ stands for "half-flat".[37] The scale of Figure 7 corresponds to the first ascending octave on this figure.

It is important to keep in mind that the equal-quartertone division was implemented very late in the history of this music, under the influence of the Western 12-semitone scale.[38] Moreover, the equal-quartertones scale is far from corresponding exactly to the intervals used in the performance of Arabian music.[39] As a matter of fact, Arabian musicology still fails to determine which were the actual intervals used in early Arabian music, albeit clues exist in the specialised literature.[40]

Before we examine these clues and use them to explain the formation of Shihāb-a-d-Dīn's scale, let us have a closer look at the scale which can be deduced from the anonymous *A-sh-Shajara*[41] and from the (a-ṣ-) Ṣafadī epistle. In these treatises,[42] the authors also use the concept of *burdāt* for the main degrees of the scale, but also *anṣāf*, which are "halves" of the intervals.[43]

The resulting scale, expressed with nowadays Arabic names of the degrees, is showed in Figure 7. The scale comprises seven so-called "tone-intervals" (but the "tone" is undefined) with their "halves",[44] which amounts to 14 intervals ("halves") per octave.

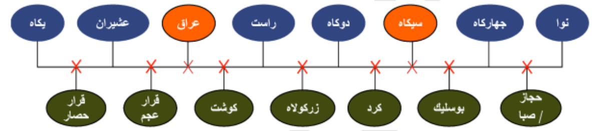



Fig. 7. The basic scale of Arabian music from *G* to *g* (left to right), with the seven *uṣūl* or *burdāt* (blue and orange ovals in succession above standing for $G\ a\ b^{hf}\ c\ d\ e^{hf}\ f\ g$ – "hf" stands for "half-flat") and the *anṣāf* (green ovals below $G^{\#}\ a^{\#}\ b?\ c^{\#}\ d\ e?\ f^{\#}\ g^{\#}$ or $a^{b}\ b^{b}?\ c^{b}\ d^{b}\ e^{b}?\ f^{b}?\ g^{b}\ a'^{b}$). The names of the upper degrees are, from left to right, *Y[Ā]KĀ ʿUSHAYRĀN ʿIRĀQ RĀST DŪKĀ SĪKĀ JAHĀRKĀ and NAWĀ*; the lower notes are (same direction) *qarār-ḤIṢĀR qarār-ʿAJAM KAWASHT ZIRKŪLĀ KURD BŪSALĪK* and *ḤIJĀZ* (or *ṢABĀ*).[45]

The study of the (a-ṣ-) Ṣafadī epistle shows that this division might have been too rough for his time, as the author uses a differentiation between "upper half" and "lower half".[46] This could have meant a division in three of the "tone-intervals",[47] or a further division in two of the "halves" resulting in "quarters" which would correspond to Shihāb-a-d-Dīn description of the scale.

However, the remaining question is to know what the nature of these "quarters" is, and how we can fit 28 "quarters" into the 24 quartertones one octave can normally contain.

## *Fitting 28 in 24*

Let us first stress that the *Rāst* scale shown in figures 3 to 6 is quite recent in Arabian music, and that the first Arabian philosophers and theorists, mostly inspired by Ancient Greek theories,[48] used scale constructions[49] which favoured a regular perfect-fourth tetrachord + perfect-fourth tetrachord[50] build of the scale based on the tuning of the *ʿūd* in fourths (Fig. 14), resulting in what is today commonly known as the scale of the *maqām Yākā* (Fig. 8, Fig. 9).[51]

As I have argued elsewhere,[52] I strongly suspect that an equal string-parts construct (Fig. 14) was the originating point of the Arabian scale; 9th and 10th century polymaths such as (al-) Fārābī and (ibn) Sīnā, who gave detailed theoretical explanations on the Arabian scale of their time, used equal-division of the string together with the Pythagorean so-called "diatonic" division in their description of the positioning of the fingers on the neck of the *ʿūd*.

| rāst | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| na | 4 | ḥu | 3 | aw | 3 | rā | 4 | dū | 3 | sī | 3 | ja | 4 | $na_2$ |
| G | 4 | a | 3 | $b^{hf}$ | 3 | c | 4 | d | 3 | $e^{hf}$ | 3 | f | 4 | g |
| | | | | | | | | bayāt | | | | | | |

Fig. 8. First of two possible representations of the *maqām Yākā* scale commonly ascribed in contemporary literature with a lower (to the left) *rāst* tetrachord (↑4 3 3 – the "↑" is used for highlighting the ascending direction of the intervals) on *G*, and with an upper *bayāt* tetrachord (↑3 3 4 beginning on *d*).[53]

| rāst | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| na | 4 | ḥu | 3 | aw | 3 | rā | 4 | dū | 3 | sī | 3 | ja | 4 | $na_2$ |
| G | 4 | a | 3 | $b^{hf}$ | 3 | c | 4 | d | 3 | $e^{hf}$ | 3 | f | 4 | g |
| | | | | | | rāst | | | | | | | | |

Fig. 9. Second of two possible representations of the *maqām Yākā* scale; this may be the original construct of the scale, with two conjunct *rāst* tetrachords (on *G* and *c*) completed (for the octave) by a "one-whole-tone" interval (between *f* and *g*).

The equal string-parts construct was used in particular[54] to determine finger positioning of the so-called "*zalzalian*" intervals, known as "neutral" intervals in most of the Western specialised literature;[55] these intervals are at the core of modern Arabian and *maqām* music, and seem to be present from the origins of this music. There is however to date no proof that this equal string-part construct was used as the main basis for the division of the octave, although strong hints of its presence are present in the early Arabian literature on music.

Nonetheless, we know that at the time Shihāb-a-d-Dīn wrote his treatise equal division of the string was in use in music theory[56] and that the favoured string instrument of the Ottoman empire (which still ruled Egypt at that time) was the *ṭunbūr*,[57] (including for Byzantine music theory and teaching – Fig. 10)[58] and that other long necked lutes, such as the *nash'at-kār*[59] (Fig. 11) usually tuned in alternated fifths and fourths, were in favour at that time and later (Fig. 12), besides evidently the introduction of the European violin in the Arabian musical instrumentarium. We also know that the most important to date Arabian Modern theorist, Mīkhā'īl Mashāqa, used the *ṭunbūr* for his theoretical demonstrations (Fig. 13).

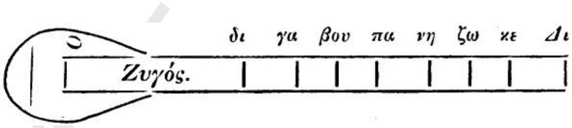



Fig. 10. Chrysanthos of Madytos' depiction of a "*ṭunbūr*", used in his explanations about Byzantine music, for theoretical purposes.[60]

So what if *Shihāb-a-d-Dīn* based his division of the octave on such an instrument tuned in alternative fifth(s) and fourth(s)?[61] The answer lies in Figure 15, which shows such a construct with a division of the octave on two strings tuned in fifth in 28 "quarters", or equal string-parts, the upper fifth being divided in 16 equal parts and the lower fourth in 12 equal parts, which together amount to 28.

The main degrees are obtained from a division of the string in 12 equal parts; then these parts are divided in two in order to obtain the *anṣāf* or "halves" of tones (which are now defined, but different from one another), with these halves divided in turn in two parts which give 4 "quarters" in one "tone", which multiplied by 7 (main "tone" intervals) amount to the 28 "quartertones" of Shihāb-a-d-Dīn.

We can deduce from this hypothesis that the resulting main scale of Arabian music in the time of Shihāb-a-d-Dīn would be *d* $e^{hf}$ *f g a* $b^{hf}$ *c' d'* (or ↑3 3 4 4 3 3 4 in standardised "quartertones" – the "↑" is for highlighting the ascending direction of the scale) which, if started on its fifth scalar degree and then transposed down an octave (starting on *G*) gives us the scale of *maqām Yākā* shown in Figure 9, with a standardised ↑4 3 3 4 3 3 4 (in quartertones) scale.[62]

In the Shihāb-a-d-Dīn's construct as I propose it in Figure 15, however, the so-called "three-quartertones" intervals of the modern Arabian theories are conceptually closer to Ṣafiyy-a-d-Dīn al-Urmawī's *mujannabāt*,[63] with a "small *mujannab*" between *d* and $e^{hf}$ on the first string (approx. 151 cents), and between *a* and $b^{hf}$ *on the second*, and a "great *mujannab*" between $e^{hf}$ and *f* on the first string, and between $b^{hf}$ and *c'* on the second (approx. 165 cents). The next intervals on the strings are the "minor tone" (approx. 182 cents) and the Pythagorean tone (approx. 204 cents).

This construct gives us a good idea of the process of the octave division and a good explanation for Shihāb-a-d-Dīn's scale, but what if some *maqām* musicologist insisted that *maqām Rāst* scale is the only scale on which the Arabian general scale may be based?

The answer to this question lies again in starting the *Yākā* scale of Figure 9 a fourth higher (beginning on *c*), which gives us the typical ↑4 3 3 4 4 3 3 scale. Another clue for this is the fact that a common tuning of the *'ūd* in the Middle-East today uses a supplementary string in the lower part of the scale, which is frequently tuned a major (or Pythagorean) tone lower than the next string, with results as a tuning in *G A d g c'* and *f'*.[64] Including the intermediate degrees $b^{hf}$ and $e^{hf}$ on the *A*- and *d*-tuned strings of Figure 14, we obtain a ↑4 3 3 4 4 3 3 scale which is the *maqām Rāst*.

This way of thinking gave me a clue as to the problematic of the 22-*śruti* scale that I shall explain in the next sections.[65]



Fig. 11. A *nashʾat-kār* made 1928 in Damascus by the famous lute-maker Anṭūn Naḥḥāt.[66]




Fig. 12. The quality and production certificate (glued in the inner part of the belly) of the *nashʾat-kār* in Figure 11.

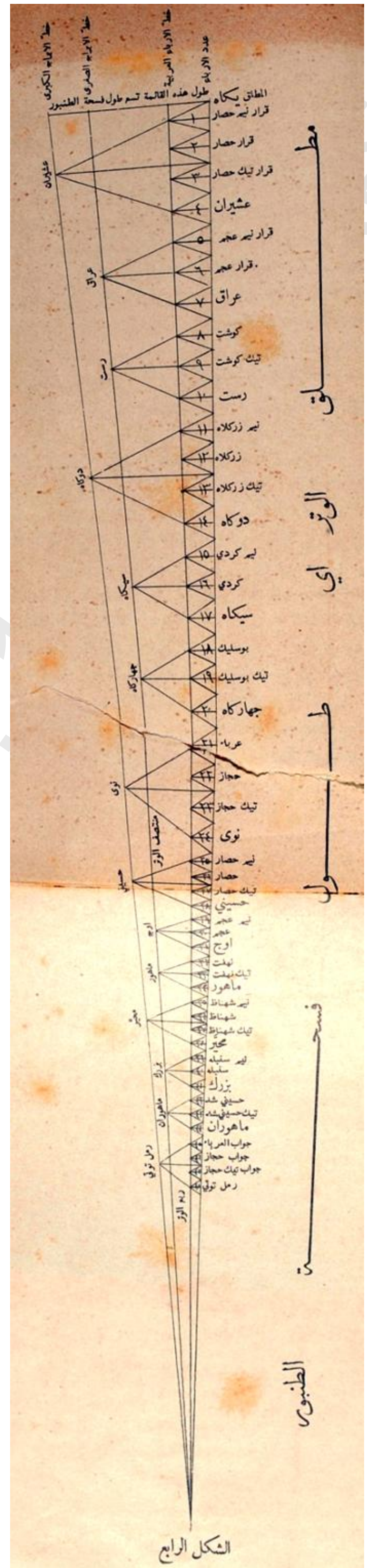



Fig. 13. Mashāqa's division of the string of the *ṭunbūr* explaining how to establish an equal-division of the octave in 24 quartertones.[67]

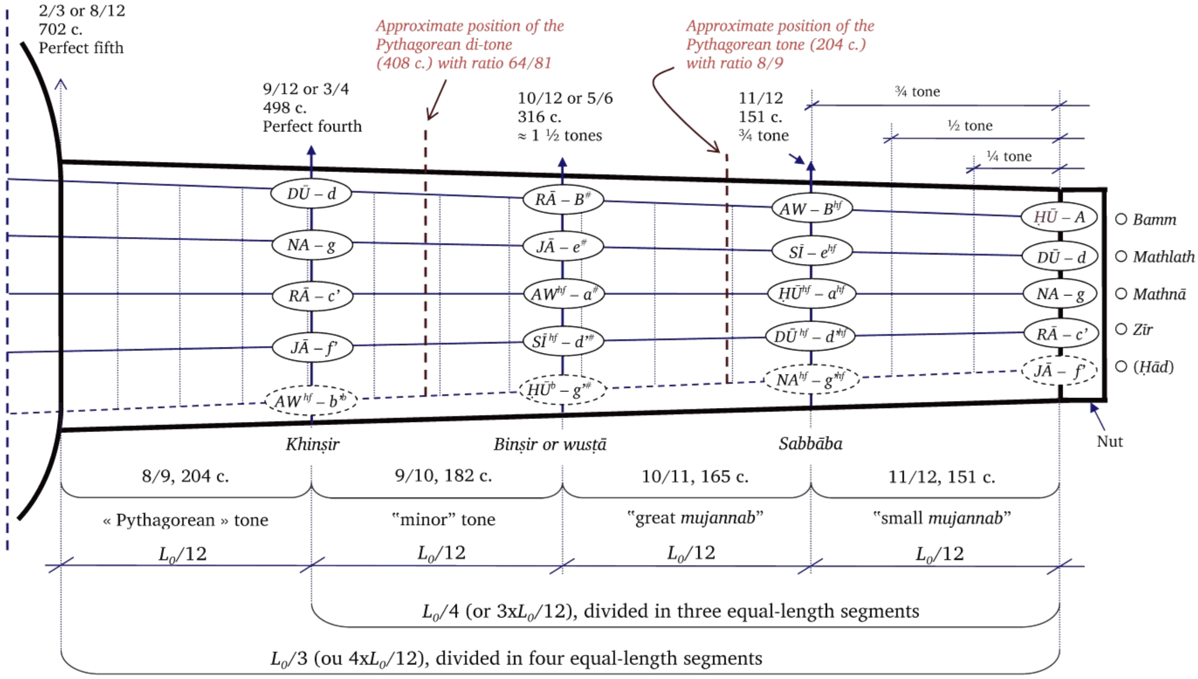
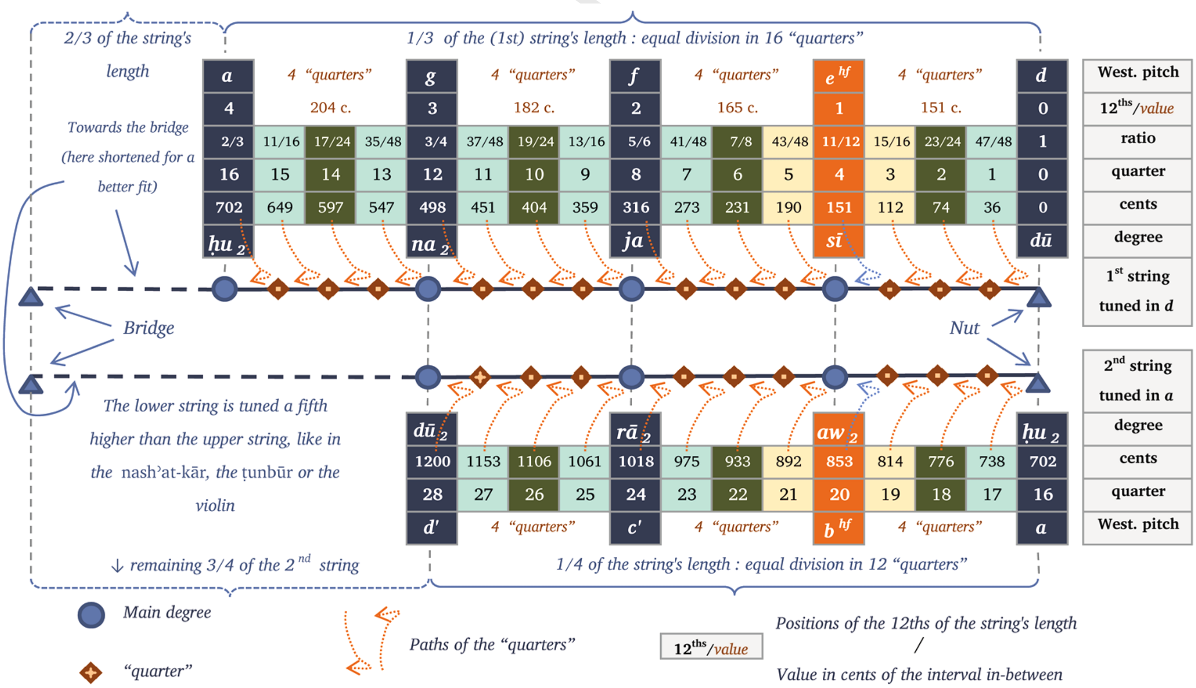



Fig. 14. The 12 equal string-parts construct based on a tuning of the *ʿūd* in fourths.[68]




| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a | 4 "quarters" | | | g | 4 "quarters" | | | f | 4 "quarters" | | | e hf | 4 "quarters" | | | d | West. pitch |
| 4 | 204 c. | | | 3 | 182 c. | | | 2 | 165 c. | | | 1 | 151 c. | | | 0 | 12ths/value |
| 2/3 | 11/16 | 17/24 | 35/48 | 3/4 | 37/48 | 19/24 | 13/16 | 5/6 | 41/48 | 7/8 | 43/48 | 11/12 | 15/16 | 23/24 | 47/48 | 1 | ratio |
| 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | quarter |
| 702 | 649 | 597 | 547 | 498 | 451 | 404 | 359 | 316 | 273 | 231 | 190 | 151 | 112 | 74 | 36 | 0 | cents |
| ḥu 2 | | | | na 2 | | | | ja | | | | sī | | | | dū | degree |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| dū 2 | | | | rā 2 | | | | aw 2 | | | | ḥu 2 | degree |
| 1200 | 1153 | 1106 | 1061 | 1018 | 975 | 933 | 892 | 853 | 814 | 776 | 738 | 702 | cents |
| 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | quarter |
| d' | 4 "quarters" | | | c' | 4 "quarters" | | | b hf | 4 "quarters" | | | a | West. pitch |

Fig. 15. An explanation of the construction of Shihāb-a-d-Dīn's scale in 28 "quarters" on the example of a "lute-type" string instrument tuned in fifth (or alternate fifths and fourths).[69]

> *"It is impossible to say with any certainty whether it was the Pythagorean, the Just Intonation, or even some other major third which was used in ancient India"*
> *Nazir Jairazbhoy* [70]

## A HYPOTHESIS ON THE FORMATION OF THE 22-*ŚRUTI*S SCALE

Twenty years ago, it would have been most unlikely that I would study Indian music. Fifteen years ago, and as I started reading about the theory of this music, it seemed an impossible task as there was only very little accessible material[71]. Ten years ago, I gave up on the *śruti*[72] system and decided to concentrate my efforts on Arabian music: there were enough riddles with this music to keep me and other musicologists busy for a few more decades.

However, and as there was more available specialised material due to digital archiving of scientific reviews and early books, I finally came across materials which, along with my continuous efforts to unveil Arabian or Byzantine music theory riddles,[73] triggered, at last, the solution that I am proposing in the present. I am first indebted to musicologists and writers, mainly Ananda Coomaraswamy[74] and Nazir Jairazbhoy[75], and to Shihāb-a-d-Dīn al-Ḥijāzī whose 28 "quartertones" I believe to be a recent replication of a concept dating to the dawn of the literate period.[76] I am also greatly indebted to Ṣafiyy-a-d-Dīn al-Urmawī whose scale with two unequal *mujannab*(s)[77] kept me busy for a long time before I could explain the fact that two intervals may be rather different in size, though conceptually equivalent.[78]

### *The conceptual similarities between the Indian* śruti *scale and the Arabian scale*

To start with, I must confess that I always thought that the Indian and Arabian Art music were based on similar general rules, but that nationalism, Western influence, the different languages or simply the superficial cultural differences were preventing them to be compared.

The main influence of Western musicology was to be found in the avoidance of references to any possible existence of "neutral" intervals in Indian music (theory) and in the generalized use of Pythagoreanism in order to explain the scale and the intervals.[79] It is mainly through the effect of this musicology on local theorists that we may explain the stress on the octave scale as a whole, and not on smaller scalar, if not melodic units, *i.e.* the fourth and the fifth. Moreover, the Western tendency to idealize music as a science, a concept which spread very quickly among local musicologist (whether Arabs, Turks, Greeks or Indians) enlisted in a competitive race trying to give their music a "respectable" basis (that is "Pythagorean"). A corollary to this is that music performance lost its role as the basis for theories, and that music theories *à la* European became the rule, apart from imposing normative instructions to the performers.

As a result of the refusal of the above influences, the hypothesis for the formation of the theory of the 22 *śrutis* I propose is based on one deduction and two assumptions.

- Firstly: the deduction to which I came after studying the internal composition of the "classical" *śruti* scale is that the ↑4 3 2 4 4 3 2 *śrutis* division found in Bharata-muni's *Nāṭyaśāstra*[80] is, conceptually, very similar to the Arabian so-called "*zalzalian* scale",[81] notably expressed by Ṣafiyy-a-d-Dīn al-Urmawī in the 13th century.[82]
- Secondly: the first assumption I made was that the two Indian and Arabian general scales are not only conceptually equivalent, but that the original "tones" (*i.e.* the 4, 3 and 2 *śrutis* "tones" and the 4 and 3 "quartertones" of contemporary Arabian theories) should also be very close in practice, if not in theory. The assumption is that these intervals should be approximately the same in the original Indian music and Arabian music, and that the resulting theoretical intervals should express, at least in their proportions, the actual differences in sizes of the intervals used in performance.[83]
- Thirdly: the second assumption is that the Indian musical scale is originally based on the fourth, and that the *vīnā* tuning should be the key to the solution.[84]

As the reader can deduce from these assumptions, I have tried to apply my knowledge of Arabian theories of scale formation to the problem of the construct of the *śruti* scale, with the results that I discuss below.

### *Is the number of* śrutis *equal to 22 in an octave?*

The *śruti* system has challenged scholars for centuries, some of them discussing and disputing even the number of *śrutis* in the octave, as Kolinski puts it:

> "[I]t is necessary to discuss the actual meaning of the allocation of twenty-two *śrutis* within one octave. For the supporters of the divisive concept it has been no easy task to arrive at the required number of *śrutis*. Hornbostel and Lachmann have attempted to trace the origin of the system back to a hypothetical instrument supposed to be related to the Chinese *K'in*. After a whole series of alterations of the actual fingerboard of the *K'in* the two scholars finally arrive at a hypothetical fingerboard of Bharata's *Vīnā* which in fact includes twenty-two *śrutis* within the octave […]; but a similar method would allow one to establish also any other desired number of *śrutis*. Fox-Strangways approaches the problem in a different way: he projects all 14 *murchanas*, that is, the whole of the theoretically possible modal varieties, mentioned by Bharata, into the same octave, but, unfortunately, gets only

twenty instead of the twenty-two expected *śrutis*; so he adds the lacking two *śrutis* 'by analogy'.[85] Danielou [*sic*], on the contrary, was forced to eliminate one *śruti* when his calculations led him to the number of twenty-three.[86] Finally, Clements' painstaking calculations yield twenty-five *śrutis* within the octave. This time, however, it is Bharata himself and the other old Indian theorists who are accused of having made a mistake, and Clements insists that the real number of *śrutis* is not twenty-two but twenty-five[87]. Still, the majority of the all-Indian Musical Conference has voted in favor of the consecrated number of twenty-two *śrutis* within the octave."[88]

Let us first note that the *śruti* is not an interval used as such in the scale, but should be considered as a "quartertone" of Modern Arabian theory, and as a component of such intervals, as Coomaraswamy writes:

> "The scale of twenty-two notes is simply the sum of all the notes used in all the songs—no musician sings a chromatic scale from C to [c] with twenty-two stopping places, for this would be a mere tour de force. The 'quartertone' or *śruti* is the microtonal interval between two successive scale notes: but as the theme rarely employs two and never three scale notes in succession, the microtonal interval is not generally conspicuous except in ornament".[89]

Let us also note that Kolinski, among other scholars, favours the harp-type *vīnā* hypothesis[90] (and the cyclic one)[91] and bases his argumentation on Coomaraswamy's article "The parts of a *Vīnā*".[92]

The simple solution that we propose for the *śrutis* scale formation is based on the (complementary) assumptions that the number of *śrutis* within one octave is effectively 22, and that the instrument cited in Bharata-muni's *Nāṭyaśāstra* is a lute-type *vīnā* (Fig. 18, Fig. 19).[93]

### *The "small" Indian tones and Urmawī's* mujannabāt

As I learned some time ago about performing *maqām Ṣabā* with my teacher and friend Saad Saab,[94] I came to the conclusion that not only the placement and intonation of the *SĪKĀ* and the *ῙRĀQ* degrees, equivalent in Middle-Eastern *maqām* theories to the Westernised $e^{hf}$ and $b^{hf}$, are subject to changes according to the organology[95] and instrument making,[96] morphology[97] and *maqām* type, but that there are also two different positionings for (for example) the $e^{hf}$[98] degree according to the *family* type of the *maqām* or of the tetrachord.[99] In concrete terms and to put it simply, the $e^{hf}$ degree is much closer to "natural"[100] *e* in the *rāst* tetrachord than it is, for example, in the *bayātī* tetrachord, although both positions are considered to correspond to the *SĪKĀ* ($e^{hf}$) degree.

As a result, in current practice the "neutral tones" or *mujannabāt*[101] in Arabian music are around 170 cents for the first, greater *mujannab* $M_1$, and around 125 cents for the smaller one $M_2$. The "one-whole-tone" interval is usually played at about 200 cents.

In the basic *maqām Rāst* of Arabian music, the scale may be (↑)$T\ M_1\ M_2\ T\ T\ M_1\ M_2$, where $T$ stands for "one-whole-tone", $M_1$ stands for "first (or greater) *mujannab*" (which is smaller than the one-whole-tone, but bigger than a semitone, whatever the latter may be), and $M_2$ stands for "second *mujannab*," or "smaller *mujannab*" (which is smaller than the *first mujannab*, but still greater than one "semitone" interval). These *mujannab* intervals fit, conceptually if not in measurements, with the description given[102] by *Ṣafiyy-a-d-Dīn al-Urmawī* about the two forms of *mujannab*, a "greater" one made out of two *limma* intervals, and a smaller one made of one *limma* + one (Pythagorean) *comma* (Fig. 16 – above). Urmawī, however, in his handling of tetrachords in Arabian music, uses the generic letter "ح" for the *mujannabāt* thus eluding theoretical differences between (L C) and (L L) as shown in Figure 16 (above); the intervals composing the *mujannabāt* intervals (Fig. 16 – below) are also approximately equal, which gives a supplementary indication in favour of an undifferentiated use of the two forms of the *mujannab* in (theoretical) practice[103].[104]

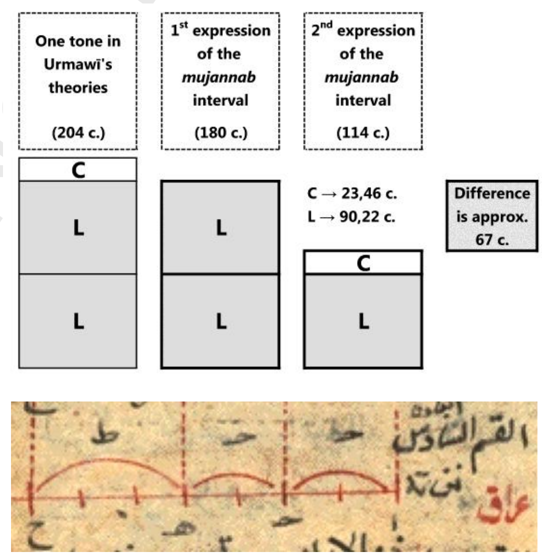



Fig. 16. Urmawī's use of the *mujannab*: (above) explanation of the theoretical values of the *mujannabāt*[105]; (below) excerpt from a Ms. of the *Book of Cycles* by Urmawī[106] showing the undifferentiated use of the *mujannabāt* by the author (the letter "ح" – or "ḥ" – above the two first intervals from the right) for the *ʿIrāq genre* (or tetrachord): both intervals "ح" (for "*mujannab*") contain (roughly) equally divided smaller "elementary" intervals which compose them.[107]

In most of the current Arabian Middle-Eastern theories, the two forms of *mujannab* are also considered as equal, theoretically, and are equated to the three-quartertones interval, with the *maqām Rāst* scale expressed as ↑4 3 3 4 4 3 3 (in equal quartertones). However, $M_1$ and $M_2$ belong to early Arabian theory, and to nowadays (and yesterday's recorded) Arabian music.[108]

It is difficult to equate the ↑4 3 3 4 4 3 3 (in theoretically equal quartertones) *maqām Rāst* scale in this form to the *śruti* main scale ↑4 3 2 4 4 3 2 (in *śrutis*) found in Bharata-muni's treatise of music, equally as difficult as to equate the 24-quartertones scale with Shihāb-a-d-Dīn's scale made up of 28 "quarters".

However, considering performance practice that the $T\ M_1\ M_2\ T\ T\ M_1\ M_2$ *maqām Rāst* scale is the closest to the intervals in praxis, we can compare this scale to the basic *śruti* scale ↑4 3 2 4 4 3 2 (in *śrutis* – see Figure 17 for an alternate formulation), on the basis that "$T$" = "4 *śrutis*", "$M_1$" = "3 *śrutis*" and "$M_2$" = "2 *śrutis*".[109] The two scales become thus conceptually equivalent, and the intervals are conceptually identical, if not (approximately) equal: the latter is the first of the two assumptions we made above; we examine the second assumption in the next section of this article.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 3 | 2 | 4 | 4 | 3 | 2 | 4 |
| *sa* | *ri* | *ga* | *ma* | *pa* | *dha* | *ni* | (*sa*) |
| 4 | 3 | 2 | 4 | 4 | 3 | 2 | |

Fig. 17. The *sa-grama* scale as explained by Kolinski[110]: The numbers in the lower row express the values of the leading (and ascending) intervals to the tone; the number in the upper row the values of the intervals between two successive tones: both interpretations have been challenged, although the ↑4 3 2 4 4 3 2 version seems to be today predominant.

### *Two assumptions and one instrument*

As I was undergoing research for my first book on Arabian music theory and practice, the preponderance of the *ʿūd* in early theories led me to undertake a detailed study of the origins of the instrument.[111] The result was that the first appearances of the short-necked (and un-fretted) lute, either in the iconography or in literature, were situated beyond any doubt in Ancient India, close to the beginning of the first millenary a.d. This predates the Islamic-Arabian *ʿūd*, and the lute-*vīṇā* (Fig. 18, Fig. 19) is probably the direct ancestor of the Persian *barbaṭ*, which seems to have been an early form of the *ʿūd*.

Short-necked lutes are commonly unfretted instruments,[112] offering versatility for interval sizes. It is often difficult to make precise measurements in order to determine fret positioning,[113] or even to draw accurately fret marks on the finger-board. Halving a length is easier, with a... string.

Should we wish to determine, for example, the position corresponding to the fourth of a vibrating string, it suffices to fold an equal length string twice, and measure with the folded string the distance from the nut.

In Early Arabian music, further (equal) division of the string-part corresponding to the perfect fourth would be an easy task, and would result in the successive tetrachords depicted on Figure 14. In the previous sections, we saw that further divisions of the resulting "tones" lead to a satisfactory interpretation of Shihāb-a-d-Dīn's scale.

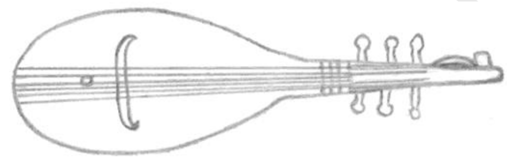


Fig. 18. Generic lute-type *vīṇā* depicted in *Amaravati, Nāgārjunakoṇḍa* and *Pawaya* (India), Gupta-period (320–480 a.d.).[114]

Now if we assume that early *vīṇā*(s) were tuned in perfect fourths, the next step would be to ask ourselves whether (and how) the string-part corresponding to the perfect fourth (*i.e.* one fourth of the string from the nut) could be divided in 9 equal parts, and what would be the result of such a division on the resulting scale.

Practically, dividing the fourth part of a string in 9 equal (more or less) parts was not challenging for the Early Indians: we have the privilege, in our time, to be able to compute very easily the resulting intervals.

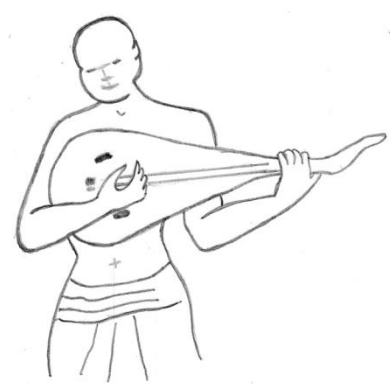


Fig 19. Line drawing of a musician playing a lute-type *vīṇā*.[115]

### *The 22-śrutis scale as an equal-division construct*

The division in 9 equal parts of the string-part corresponding to the perfect fourth on the lute-type *vīṇā* is shown on Figure 20.

Dividing the first string (the upper string tuned in *G* in Figure 20) into 36 equal *parts* (*i.e.* of equal length), with 9 parts to the (perfect) fourth, we obtain a division which reproduces the *śrutis* spread in a perfect fourth as described in the Bharata-muni's *Nāṭyaśāstra*, *i.e.* three "tones" in the fourth, with corresponding numbers of *śrutis* 4, 3 and 2. Let us call the first tone, with the 4 first *śrutis* (equal parts of the string), "Pythagorean," as its length ratio is 8/9 [as (36-4):36 = 8/9]. It measures 204 cents.

We may decide to name the second "tone" "first (or greater) *mujannab*", similarly to the Arabian theory.[116] This *first mujannab* is made up of 3 *śrutis* (equal parts of the string divided in 36). It is theoretically equal to 170 cents. As for the *second mujannab*, it is made up of two *śrutis* (*idem*) and equates to 124 cents. We find equivalent "tones" in the second string, for the second perfect fourth (*c-f*). We thus obtain 6 degrees of the scale, containing successively 4 3 2 4 3 and 2 *śrutis*. The remaining "one-whole-tone" is obtained on the third string, with the resulting ↑4 3 2 4 3 2 4 scale (in *śrutis*).

Thus, *śrutis* are at the same time "equal" (as equal parts of the string) and "unequal" (as intervals measured by modern scientific methods[117]). Their exact value varies between 49 and 63 cents, with an average value of 55 cents.[118] This could explain why *śrutis* are considered as equal in Early Indian writings on music and that these *śrutis* are taken as unequal.[119]

Furthermore, transposing any scale in such a division[120] of the octave would result in small discrepancies due to the different sizes of the *śrutis* depending on their position on the fingerboard; this probably means that this division was taken as an *indication* for the effective positions of the fingertips on the fingerboard, *and* that this fingerboard was, consequently, *not* fretted.[121]

### *Short discussion about the outcome*

One of the objections to the theory of the 22-*śrutis* scale as an equal-division construct could be that the ↑4 3 2 4 3 2 4 scale is different from the ↑4 3 2 4 4 3 2 scale (both in *śrutis*), and that the scale deduced from Figure 20 begins on *pa* (G) and not on *sa*: my answer would be that the most important feature in this scale is the composition of the fourth, which is 4 3 2, and that by combining a fourth (4 3 2) with a one-whole-tone (4) and another fourth (4 3 2), we obtain *sa* 4 *ri* 3 *ga* 2 *ma* 4 *pa* 4 *da* 3 *ni* 2 *sa*.

Let us also remember that:

- Transpositions in fourths (or fifths) are frequent in melodic music, mostly whenever string instruments tuned in fourths (or fifths) are used in performance.
- Arabian lutes have a "zero" string that is very frequently (commonly) tuned in a "one-whole-tone" step with the first (second) string,[122] which gives us, if we start the scale a "one-whole-tone" lower, ↑4 4 3 2 4 3 2 (in *śrutis*). By starting the scale on the fifth degree we obtain *sa* ↑4 *ri* 3 *ga* 2 *ma* 4 *pa* 4 *da* 3 *ni* 2 *sa*.

Again, the octave is irrelevant in this matter since the fourth seems to prevail in Early and more recent[123] modal music.[124]

Now, with regard numbers 9, 4, 3, 2, and others that can be deduced from Figure 20, such as 36 (equal-parts of the string) and 29 (as the numerator of the 29/36 ratio of $e^{hf}$ and $b^{hf}$) what can be said? There may be religious or cultural explanations for those numbers, but I cannot resist the urge to propose another, simple explanation for their use in the construct.[125]

I have explained elsewhere[126] how numbers of small intervals composing a bigger conceptual interval can be used as qualitative markers for these intervals; in Ṣafiyy-a-d-Dīn's theory of the scale, for example, the two *mujannab*(s) each host two intervals (Fig. 16), although the exact theoretical measures of this two-form interval are different. Conceptually, however, the two forms of the *mujannab* are considered by Ṣafiyy-a-d-Dīn (al-) Urmawī as being the same interval.

If we think of the numbers of *śrutis* amounting to an interval in the 22-*śrutis* scale, the 4, 3 and 2 clearly define different intervals, conceptually, although the exact measures of these intervals may slightly vary because of the positions of the *śrutis* on the fingerboard of the *vīnā*. The question arising in this case is "why not begin with number 1 and use 3 2 and 1 for $T$ $M_1$ and $M_2$?" The answer to such question can be given in three argumentative parts:

- Firstly: the numbers of small intervals composing the greater conceptual intervals must somehow reflect the actual sizes of the intervals; in this case, 124/204 as a ratio of cents value between the smallest "tone" (the "small *mujannab*" $M_2$) and the "Pythagorean tone" of the 22-*śrutis* scale (Fig. 20) is closer to 2/4 (or 1/2) – which is the ratio of the *śrutis* contained in the corresponding intervals – than 1/3 in the other version.[127]
- Secondly: the 4 3 2 division of the fourth gives a perfect match for the Pythagorean tone as the result of the ratio 8/9, whenever 3 out of 24 divisions in all[128] in the "3 2 1" partition results in a 7/8 ratio.[129]
- Thirdly: the 29/36 ratio (374 c.), which may seem awkward at first, is a close match to the much simpler 4/5 ratio (approx. 386 c.),[130] and a practical way of approximating the latter.[131]

Another question that may arise is "why then only 9 *śrutis* in a fourth and not 10, 12 or more for more accuracy?". There is a much simpler answer to this question: the main aim of this division of the octave was not *normative*, but *indicative*. In other words, the first objective of such a division would be to give simple *qualitative*[132] indications to the performer as how to perform a mode, and not to determine the exact sizes of the intervals in use.[133]

## CONCLUSION

The equal division of the string is a plausible hypothesis for some of the scale constructs found in the *maqām* and other forms of modal music.

In this paper, I give two of these constructs, one of which is a full illustration of *Shihāb-a-d-Dīn*'s "28-quarters" scale; in the case of the 22-*śrutis* scale, further research is needed in order to determine whether the equal string-division may give answers and clues beyond the discussion undertaken here.[134] If such a hypothesis receives confirmation with Indian music, it would be legitimate to postulate that the introduction of the Western concept of "neutral" (*i.e.* "foreign") and "equal" intervals alongside (ironically) with the use of Pythagorean and just intonation concepts, and the evolution of concepts that ensued, transformed the Early *indicative* and *conceptual* theories into *normative* and *measuring* theories.[135]

This explains how the intervals which were in use until recently in the history of modal music were approximate,[136] tended to become fixed-sized intervals.[137] The normative trend represented by either equal-temperament or Pythagorean incantations to "science" prevent today most musicologists from understanding the basis from which early theories are built. This leads to very complicated explanations on phenomena which could well be, in substance, quite simple: these theories were mainly, if not all, conceptual in their essence, especially in the absence, in Ancient times, of accurate means of measuring intervals sizes.[138]

It suffices however to put aside Western misconceptions about modal music in order to find clues about early (or less early) theories, and to determine how they were distorted in the West, then afterwards or in parallel, in autochthonous modern musicology.[139]

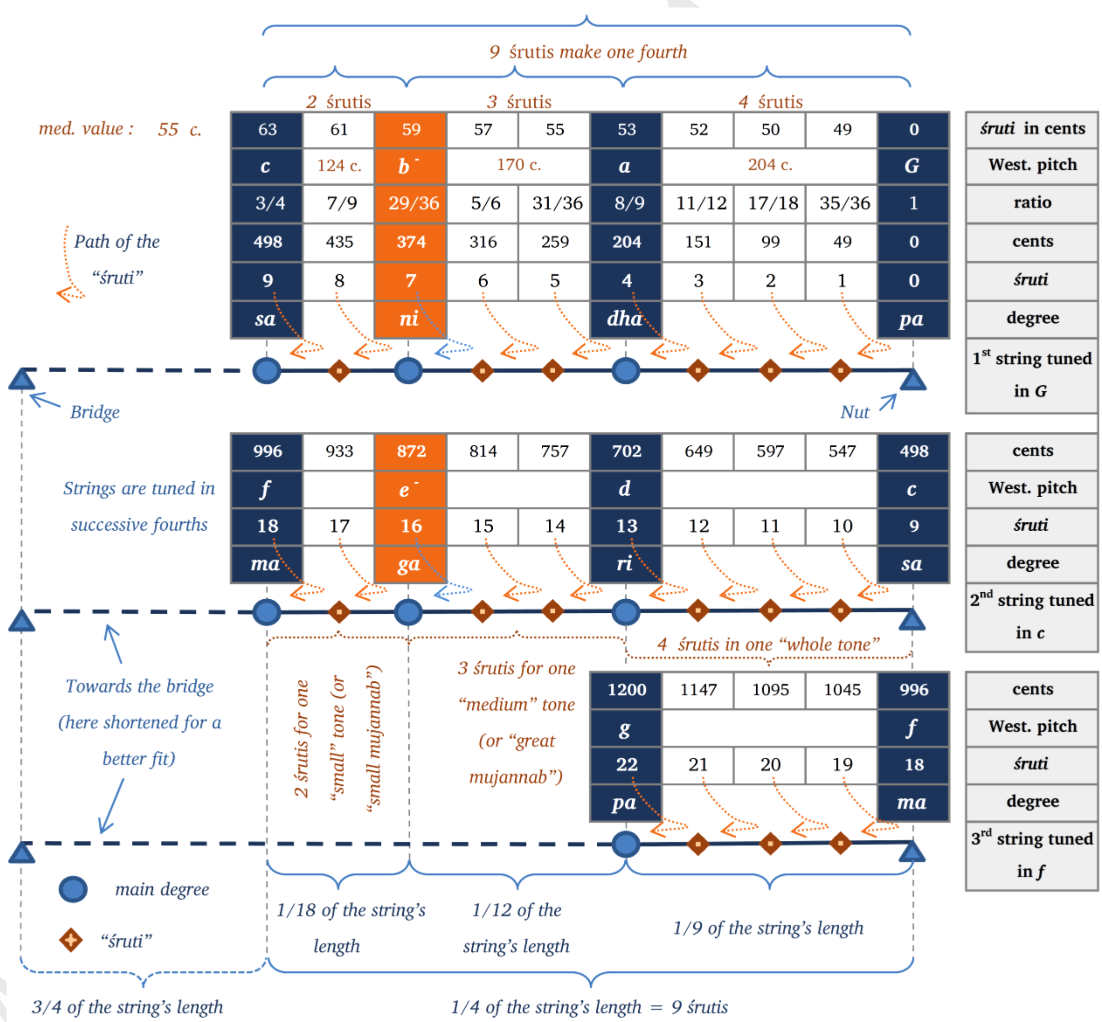



Fig. 20. Construction of the *śruti* scale based on a division in 9 equal parts (*śrutis*) of the fourth of the strings of the lute-type *vīnā*.[140]

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Notes

[1] "*Unveiling the repetitions of the scholars* [another meaning for *aḥbār* is priests] *in explaining the modes.*" The three parts of the title are built in rhymes, as were often titles of poems and musical treatises in Arabian musicology. *Kashf al-Asrār*, or "Unveiling the secrets (of)" is a common beginning of titles of poems and treaties found in a wide panel of Arabian writings. The first part of this article is a tribute to my predecessors, mainly in the 19th and the 20th century, who "unveiled" much. *Karkara[t]* means "repetition", and finds its contextual meaning with the following word *aḥbār*, which means "prelates", "scientists", "scholars" – see [Maʿlūf, 1997, p. 678 & 113]. Most of the authors of the music "riddles" in modal music were prelates, who also happened to be scientists and scholars: these Uhr-musicologists have repeated the same or similar pattern of constructing the scale, albeit with differences in the details! As for *taʾwīl al-adwār*, the first term means

"explanation, interpretation, connected with" – see [Maʿlūf, 1997, p. 21], and *adwār* is used, at least since Safiyy-a-d-Dīn [Urmawī (al-), 1980; 1982; 1984; 1938] in the 13th century, as the original description of what could be called today a "modal scale" (an accurate study of the different ways of describing scales in relation to their modal characteristics is planned in [Beyhom, 2014], forthcoming). As a result, the title of this article is a tribute to all those, often prelates and scholars with cheerful spirit, who tried to explain, elucidate or transmit the problematic of the modal scale. As Ernest McClain affectionately put it in a recent correspondence [2012], "[t]he foundational attitudes of *Rg Veda* scribes is one of great amusement with themselves; it was pure genius to describe themselves as Holy Priests as 'frogs croaking around a pond'".

[2] "By way of introduction". I would like here to thank François Picard, Professor at the Université de la Sorbonne and Scott Marcus, Professor at the UCSB, both being members of the Academic Board of NEMO-Online, for their useful (and numerous for the latter) comments, corrections and suggestions. I would equally like to thank Richard Dumbrill, our most respected administrator, for the huge amount of time he spent correcting my English.

[3] Plural of *urjūza*, a poem in the *rajaz* (corresponding to *mustafʿilun* six times) prosodic meter ([Abdelnour, 2008, p. 62 & 69], [Maʿlūf, 1997, p. 250]).

[4] I use the plural for *śruti* with an "s" (*śrutis*), for reasons of convenience.

[5] For example the *lo-go* scales in my thesis [Beyhom, 2003b, p. 230–234 & 269–283], with variable numbers of intervals to an octave.

[6] See for example [Beyhom, 2003b; 2006a; 2006b; 2007a; 2007b; 2007c; 2007e; 2010a].

[7] Whose writings I could read only in some European languages.

[8] Mainly Pythagorean as I have tried to show in [Beyhom, 2010c], and as I plan to further demonstrate in [Beyhom, 2014] (forthcoming).

[9] In the meanwhile, the publication of my first book and the foundation of a research centre on Arabian music took also a lot of time and energy.

[10] The habit of differentiating music(s) whose general (and most important) features are so close that they should be originated from the same point: I document the influence of this nationalist attitude on the music in different regions of the *maqām* realm in [Beyhom, 2014] (forthcoming).

[11] Our main sources for Shihāb-a-d-Dīn's biography are [Ziriklī, 1980, v. 6, p. 38] and [Shiloah, 1979, v. 10, p. 327–328].

[12] A Muslim title for religious dignitaries, commonly translated as "Sheikh".

[13] Born in Mecca, in the *Ḥijāz* (Arabia).

[14] There are a few manuscripts predating the published version of Shihāb-a-d-Dīn's treatise [Ḥijāzī (al-Makkī al-), 1864], of which we know [Ḥijāzī (al-Makkī al-), 1843; 1855]; the latter are sometimes more accurate and were helpful in correcting typographical mistakes in the printed book as shown in Figure 2.

[15] See for example [Marcus, 1989, p. 71–72].

[16] This was for example the claim of Fatḥī (al-) Khamīsī, an Egyptian musicologist, during a conference organised by the Arab Academy of Music (AAM) in Cairo in 2007 [*The 1932 Congress on Music in Cairo, 75 years* (*A critical approach of the 1932 Congress on Arabian music held in Cairo in 1932*)]. This musicologist kept speaking in his conference about the "24-quartertones scale of Shihāb-a-d-Dīn," and refused to answer our questions (with a few colleagues) about the fact that Shihāb-a-d-Dīn clearly defines a 28-step scale in his treatise (the 28 "quarters") and not a 24-step scale.

[17] Mashāqa has wrongly been ascribed as the "inventor" of the 24 quartertones scale common nowadays in the Middle-Eastern music theories: for a discussion on this matter and the fact that al-ʿAṭṭār, as Mashāqa ascribes it, was well aware of this division, see Ronzevalle's argumentation in [Mashāqa, 1899b, p. 4–5], or our [Beyhom, 2014] (forthcoming).

[18] Also called *maqāmāt* (plural of *maqām*).

[19] I use the following conventions for Arabian notes, tetrachords and modes (*maqāmāt*) names: a note name is written in capital letters, such as the degree *RĀST* (equivalent to the Western *c* in the Arabian contemporary theories of music); a tetrachord name is written in small letters, for example *rāst* for the tetrachord composed (in the same theories) of three successive ascending intervals comprising 4, 3 and quartertones each; as for the *maqāmāt*, I write them with a first (initial) capital letter, such as for *maqām Rāst*. This differentiation is helpful in such cases when all three *RĀST* note-degree, *rāst* tetrachord and *Rāst* mode bear the same name (please refer to the introductive part of my first volume on Arabian music [Beyhom, 2010c, v. 1, p. xvii–xxiv] for detailed information about the reasons underlying the use of *YĀKĀ* instead of *YĀKĀH* for example, or for other peculiarities of the transliteration).

[20] This should be "*SĪKĀ*" as in the Ms. *z* 2935 (Fig. 2).

[21] The author uses here the terms *masāfat al-buʿd*, which means "the distance of the interval" or, in another interpretation, "the distance corresponding to the interval".

[22] [1864, excerpts from pages 11, 12, 13, 14 and 15].

[23] This lithographic version is referenced as *li* 1864 in this article.

[24] [Ḥijāzī (al-Makkī al-), 1864, feuillet 4 vº].

[25] The story of this evolution is complex and ascribed in [Beyhom, 2014] (forthcoming): we use in the following figures the standard contemporary names of the *burdāt* and *ʿarabāt*.

[26] Erlanger [1949, v. 5, p. 11–12] explains briefly the evolution of the names for these degrees.

[27] Degrees with orange background are the "neutral" *e* and *b* "half-flat", and the degree *na* (G *or g*) determines the octave passage.

[28] Or *ŪSHSHĀQ*.

[29] Or *NĪRIZ*.

[30] The vowels of most of these names may be different because of the lack of the former in the copy; the names are cited on [Ḥijāzī (al-Makkī al-), 1864, p. 14].

[31] The *ʿarabāt* figure on a dark green background (middle), the *tīkāt* and the *nīmāt* on light green-blue and green-orange backgrounds. The result is a scale divided in 28 conceptually equal "quarters" (column to the right).

[32] We find clues to the latter and to the names used for the *maqāmāt* in two previous works on Arabian music, the anonymous *A-sh-Shajara dhāt al-Akmām al-Ḥāwiya li-Ūṣūl al-Anghām* [Anonyme, 1983], and the treatise on music of *a-ṣ-Ṣafadī* [[Ṣafadī (a-ṣ-)], 1991]: Ṣalāḥ-a-d-Dīn a-ṣ-Ṣafadī lived from 1296 to 1363; some Arabian scholars told me in verbal communications that this epistle may be falsely attributed to him; they did not produce, however, any proof for the latter, and I continue for the time being (until further information is retrieved on this epistle) to use the name of Ṣafadī as the author of the *Epistle in the science of music*, albeit between square brackets in order to show that there may be an issue with the authorship. Detailed explanations about the two treatises cited can be found in [Beyhom, 2014] (forthcoming).

[33] [Caron and Safvate, 1997, p. 26].

[34] May they be "one-tone" or "three-quartertones" intervals.

[35] Let us note here that a certain Ibrāhīm Muṣṭafā seems to have developed a similar division of the octave, or argued about it, as writes Ghrab [2005, p. 71]: "Meanwhile, we have to notice the work of Ibrâhim [*sic*] Bey Mustafâ [*sic*], […] who contends that all *bardāt* [the main intervals of the heptatonic scale] are divided into four parts to get 28 intervals by octave." Ghrab cites as a reference for this author "the article of Ibrâhim [*sic*] Bey Mustafa, *La valeur des intervalles dans la musique arabe [Value of intervals in the Arabic music]*, Bulletin de l'Institut Egyptien, II, 1888". We could not find this article, but it would have surely been an interesting addition to the Egyptian point of view on Shihāb-a-d-Dīn's division of the octave.

[36] In Erlanger's descriptions of the Arabian general scale, transliterations of the names differ from ours and from other authors' transliterations: this is a complicated matter as each European nation as well as various authors have used their own transliteration. Attempts have been made to unify the transliterations of Arabian terms, and two main systems co-exist today, one of which used in the *Encyclopedia of Islam* while the other is used in the *New Grove*. I explain in my first volume on Arabian music (please see also note No. 19) the reasons why I think these transliterations should be adapted to fit more closely the pronunciation rather than the lettering of the Arabic terms.

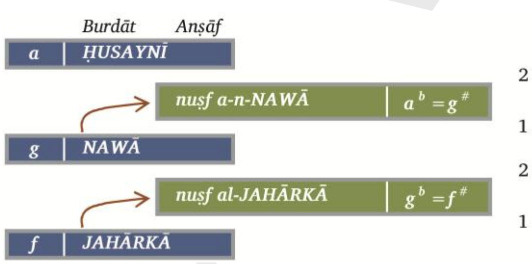
[37] [Erlanger, 1949, v. 5, p. 13 – Fig. 3]: reproduced by kind permission of the publisher.

[38] For more details on this phenomenon see [Beyhom, 2014] (forthcoming).

[39] See [Beyhom, 2001 ; 2003b ; 2006a ; 2007c] for more details.

[40] See [Beyhom, 2005 ; 2006a ; 2006b ; 2007a ; 2007b ; 2007c ; 2010c].

[41] A few clues to this scale are given in [Beyhom, 2005], notably in the sections concerning figures 3.15 and 3.17 [p. 84 and 88], and figures 3.21 to 3.23. Figure 3.15 explains, notably, how the tuning of the *ʿūd* in fourths have probably affected the scale (or reciprocally), and how the one-tone-and-a-half intervals resulting from this tuning were probably divided in two equal parts (of the string or of the interval?) which led in turn to the *zalzalian* general scale. The resulting scale deduced from the *A-sh-Shajara* treatise is shown on Figure 3.17 [Beyhom, 2005, p. 88]. The base for this scale is proposed in the figure below.

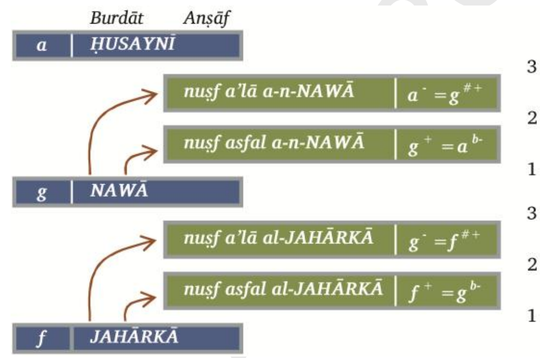


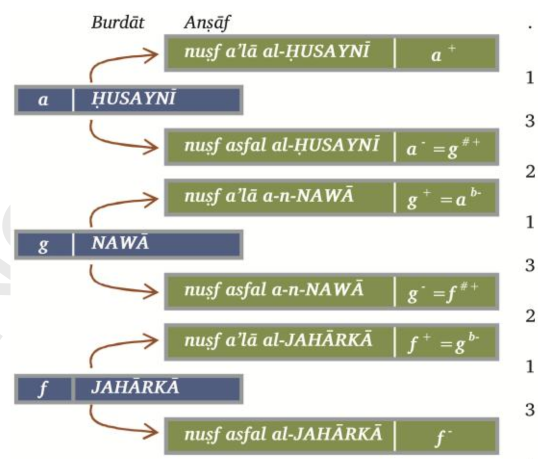

The most probable position of the *nuṣf* of a *burda* (degree of the Basic scale) is the upper one (this seems the case for all the "halfs" cited in the *A-sh-Shajara* treatise, independently from the movement of the intervals, *i.e.* ascending or descending). Please note that *burda* (pl. *burdāt*) = "degree" or "interval"; *nuṣf* (pl. *anṣāf*) = "half"; *muṭlaq* = "free"; *muqayyad* = "tied"; *aʿlā* = "higher, [*aʿlā min*] higher than"; *asfal* = "low, lower, [*asfal min*] lower than".

[42] Written probably around the 14th century or later (probably not later than the 17th century – see [Beyhom, 2014], forthcoming).

[43] For this and all details concerning the *A-sh-Shajara* and the (a-ṣ-) Ṣafadī epistle, please consult [Beyhom, 2014] (forthcoming).

[44] Other representations of the scale, mainly in the (a-ṣ-) Ṣafadī epistle, are possible and are shown explicitly in [Beyhom, 2014] (forthcoming). Two possible explanations of the "upper" and "lower" positioning of the *anṣāf* are provided on the figures below.

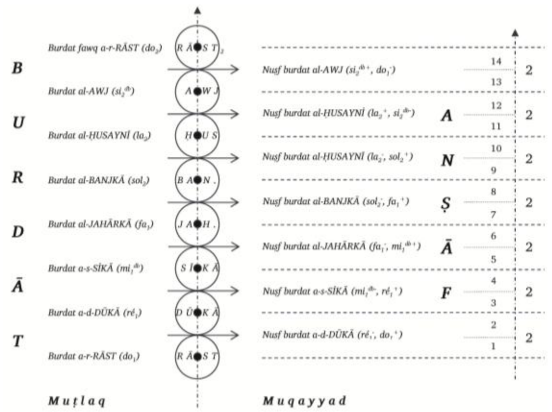



[45] The anonymous author uses expressions like (here for example for the mode *Zinkulā* [Anonyme, 1983, p. 56] – please note that *Zinkulā* {for the mode} is another transcription of *ZĪNKŪLĀ* {the degree of the scale}): " [then] you ascend [from the *JAHĀRKĀ*] to the half of the *burda* of the *BANJKĀ*", or "تصعد إلى نصف بردة البنجكاه". The following figure (below – which is an excerpt of [Beyhom, 2014], forthcoming) shows a possible conceptualisation of the *A-sh-Shajara* scale following diverse indications given in the treatise (including the numerous *formulae* in the treatise describing the "modes"). The main degrees (the *burdāt* on the left, also called *muṭlaqāt*) are seven with each a corresponding *nuṣf* ("half") to the right (the *anṣāf* are also called *muqayyadāt*); the total number of successive intervals between the *burdāt* and the *anṣāf* is 14. The main degrees of the scale are (ascending) *RĀST* → *DŪKĀ* → *SĪKĀ* → *JAHĀRKĀ* → *BANJKĀ* → *ḤUSAYNĪ* → *MAQLŪB* [I use "*AWJ*" – the common modern name – instead in the figure] → *Fawq A-r-RĀST*. The circles shown on the figure are a possible interpretation of the phrase "the characteristics of the *muqayyada* and the *muṭlaqa* are that for the *muṭlaqa* the line going through the centre of the eyes arrives at the centre of the circle, and that for the *muqayyada* the said line arrives on the periphery":

("[...] وعلامات المقيدة والمُطلقة، في أصول الشجرة وفروعها، أنّ المطلقة يكون الخطُّ المارُّ بمراكز واصلاً إلى مراكز الدائرة، والمقيدة يكون الخط المذكور واصلاً إلى محيطها [...]")، –

in [Anonyme, 1983, p. 36].




[46] This problematic was clarified in [Beyhom, 2007a ; 2007e ; 2010b] ; a detailed discussion of the scales resulting from this interpretation are to be found in [Beyhom, 2014], forthcoming (see also endnote No. 47). The following are two excerpts giving an example of differentiation between upper and lower *nusf* (singular of *anṣāf*):

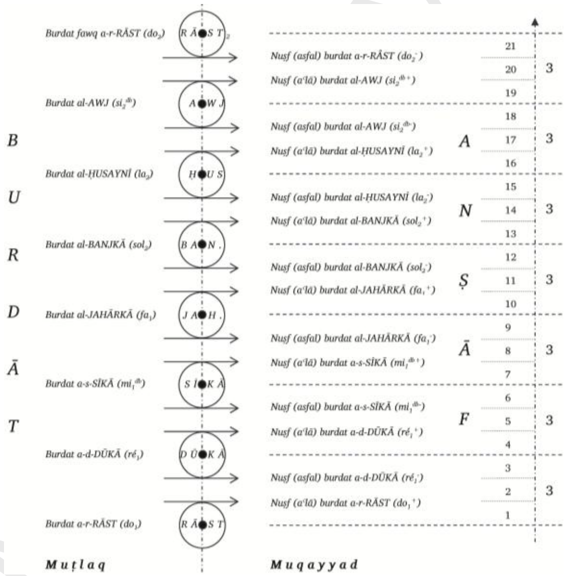
"من البنجكاه هابطًا إلى نصف بردة الجهاركاه، ثم إلى السيكاه ثم الدوكاه وتمدّ فيه مدًّا، ثم تُسقِط بردة السيكاه وتصعد دفعة إلى النصف الأعلى من الجهاركاه".

Concerning the mode *H[a]umāyūn*: "[from the *BANJKĀ*] descending to the half of the *burda* of the *JAHĀRKĀ*, then to the *SĪKĀ* then to the *DŪKĀ* and you rest on [it], then you avoid the *SĪKĀ* and you go up in one movement the upper half of the *burda* of the *JAHĀRKĀ*" – [[Ṣafadī (a-ṣ-)], 1991, p. 152].

"تهبط [من البنجكاه] إلى النصف الأسفل من بردة الجهاركاه".

Concerning the mode *Nūrūz-ʿArab*: "descend [from the *BANJKĀ*] to the lower half of the *burda* of the *JAHĀRKĀ*" – [[Ṣafadī (a-ṣ-)], 1991, p. 153].

[47] This division (below) is effectively one of the solutions for the explanations of the (a-ṣ-) Ṣafadī epistle on the composition of the modes – *cf.* [Beyhom, 2005 ; 2007a ; 2007e ; 2010b ; 2014 – forthcoming] and the figure below (which is also an excerpt from [Beyhom, 2014], forthcoming).




[48] Most notably (al-) Fārābī and (ibn) Sīnā – please see [Beyhom, 2010c] for more details.

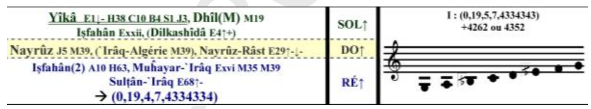
[49] For other details on the scale construction of the Arabs from the 9th to the 13th century please see [Beyhom, 2010c].

[50] To which a "disjunctive one-tone" interval is added in order to complete the octave. The « one-tone » interval was added in all possible three positions, before, between or after the two tetrachords.

[51] The tetrachords are considered to be based on open strings, as with *Ramal-Māya* (↑3 3 4 3 3 4 4 in standard Modern quantification in quartertones) or *Ḥijāzayn* (or *Ḥijāz-Gharīb*– ↑2 6 2 2 6 2 4) in Arabian music – see for example [Beyhom, 2003c, p. 56] and [Beyhom, 2010b, p. 34].

[52] Most notably in [Beyhom, 2010c].

[53] Other *maqāmāt* using this scale can be found in [Beyhom, 2003c, p. 57 – see hypersystem 4334334], of which an excerpt corresponding to the ↑4 3 3 4 3 3 4 scale is proposed below.




[54] Also by Ṣafiyy-a-d-Dīn al-Urmawī in his *Risāla a-sh-Sharafiyya fī-n-Nisab a-t-Taʾlīfiyya* – *cf.* [Beyhom, 2007a ; 2007e ; 2010a ; 2010b ; 2014].

[55] I follow here Owen Wright's usage of the term *zalzalian*: "We shall term all species and scales containing neutral intervals Zalzalian, whether or not the *wusṭā Zalzal* itself would have been used to produce them" – in [Wright, 1978, v. 28, p. 82, note No. 4]. The establishment of the *zalzalian wusṭā* on the neck of the *ʿūd* is explained for example in [Wright, 1978, v. 28, p. 31–32].

[56] For example the division of half the string's length in 24 quarters that Mashāqa attributes to Sheikh *al-ʿAṭṭār* in Damascus (see also note No. 17 on Mashāqa above). This constitutes yet another riddle for which I give clues in [Beyhom, 2014].

[57] See [Hassan et al., 2007], [Farmer and Chabrier, 2000] and, for a detailed discussion on the *ṭunbūr* and the *ʿūd*, *Appendix A* in [Beyhom, 2010c].

[58] In what concerns the teaching and practice, please see note No. 60.

[59] "The [*nashʾat-kār* is] a half-size Turkish *ʿūd* with guitar pegs and six courses, used to be played mainly by amateurs ; like other relics of Turkish influence, it has almost disappeared" – in [Hassan, 2001].

[60] [Chrysanthos (de Madytos) and Pelopidēs, 1832, p. 28]. The title states: "The diatonic scale on the diapason system, on which the beginners are taught the quantity of melody" (in [Chrysanthos (de Madytos) and Rōmanou, 1973, p. 24]). Chrysanthos explains: "Among the melodic instruments the one that appears easier for teaching and the one found to be the most clarifying for the learning of the tones, the semi tones and, simply, of all the intervals, is the *pandouris*. This is also called *pandoura* and *pandouros* and, by us, *tamboura* or *tambour*. It has two parts, the body and the neck. On the neck the tones and semitones can be fretted" – in [Chrysanthos (de Madytos) and Rōmanou, 1973, p. 17, note No. 2]. Rōmanou (the translator and editor of Chrysanthos' treatise on Byzantine music *Theōrētikon mega tēs mousikēs*) further comments [Chrysanthos (de Madytos) and Rōmanou, 1973, p. 267]: "These names—in addition to *tambouras* and *tambourin*—designated in Byzantine and post-Byzantine periods the instrument known today as 'bouzouki'. (In Crete the name *tamboura* is still in use today.) The instrument has three pairs of strings at the intervals of a perfect fifth and a perfect fourth and is played with a plectrum. Its size varies from 0,70 m. to 1,00 m".

[61] There is no evidence that Shihāb-a-d-Dīn worked with an instrument tuned with two strings a fifth apart, and we can not be sure

that such an instrument was used by him for his theoretical and practical researches on music (if any); we know however that these instruments were contemporary to the author and that other theoreticians of the same period, such as Chrysanthos (for Byzantine Chant) and Mashāqa (for Arabian music) explained their theories with the help of the *ṭunbūr*. It would be most probable, anyhow, that a theoretician would use a lute-type instrument (with stoppable strings) for the establishment of his theory rather than his voice which would be to the least hesitant for the establishment of the degrees of the scale, especially for the intermediate notes between the main degrees; hints exist in the specialised Arabian literature concerning the use of instruments (in the following citation most probably a lute-type string instrument) for a better location of the degrees of the scale, like this one in [Anonyme, 1983, p. 37]:

”وأعلم أيضًا أن تلك النصفُ البُردة التي نبّهنا عليها هي نصف نغمة ومنها إلى نصف أُخرى نغمةٌ كاملة، ثم إلى نصف أخرى نغمة كاملة ثالثة، وهكذا إلى جوابها، وإدراك ذلك بالحلق صعبٌ جدًا وبالآلة يُعرف حقيقة قولنا هذا، لأنّه بالآلة يمكن ظهرة نغمتين وثلاثة بين بعدين، لكن متنافرات“،

"And know also that the *nusf al-burdā* [« half of the interval »] we already cite is half of a *naghma* [« melodic sound, note, degree, interval »] and from it to another half [you get] a complete *naghma* [you get to the next degree of the scale] then to the half of another a [then a] complete [second then] third *naghma*, and so on until the octave, [knowing that] it is difficult to perceive this with the voice [only] which makes it possible to know the truth of our present saying only through the use of [musical] instruments, because we can produce [with it] two or three notes between two distances, but they would be dissonant".

Beyond the difficulty of properly translating this passage, this is also a hint on the possible recourse to a division of the main intervals of the scale in three parts, as in the (a-ṣ-) Ṣafadī treatise.

62 The *Rāst* scale with interval values (ascending) ↑4 3 3 4 4 3 3 would be found starting logically on *c*. Following this reasoning, the common Basic scale of the Arabs, as given in Figure 14, would then be a *Ḥusaynī*-type scale ↑3 3 4 4 3 3 4 (traditionally based on *D*) based on *A*.

63 See [Beyhom, 2010a, p. 177 – Fig. 5] and the next sections devoted to the *śruti* scale.

64 The *G* string is today often tuned in *F* in order to obtain a double octave from *F* on the first string till *f'* on the sixth string.

65 Please note that both scales deduced from the *A-sh-Shajara* treatise and from the (a-ṣ-) Ṣafadī epistle may also be conceptualized as equal divisions of the string: a detailed treatment of this problematic is planned (as already mentioned) in [Beyhom, 2014] (forthcoming).

66 This instrument belongs to Saad Saab (Lebanon), who took the pictures for this and the next figure.

67 [Mashāqa, 1899a, plate inserted between p. 1076 & p. 1077].

68 Adapted from [Beyhom, 2010c, v. 1, p. 99 – Fig. 40]: this figure represents a stylised finger board of a common *ʿūd*; the vertical grid with fine blue lines shows the (approximate) positions of exact quarters of the tempered tone. The first *mujannab* (commonly known as "neutral tone" in Western specialised literature) resulting from this division (to the right) measures approx. 151 cents, and the second *mujannab* approx. 165 cents; "hf" stands for "half-flat" and "+" for "one *comma* plus" (with the "comma" approximately equal to 24 cents) alteration. The "minor tone" between the *binṣir* ("ring finger" or "annular") and the *khinṣir* finger ("little finger" or "auricular") positions measures 182 cents: the "major tones" in this construct lie between the perfect fourth and fifth. The fifth lower string was as a rule hypothetical; its first known appearance in practice is mentioned in the 11th century by (ibn a-ṭ-) Ṭaḥḥān al-Mūsīqī (see the edition by Neubauer [Ṭaḥḥān (ibn a-ṭ- ~ al-Mūsīqī), 1990, p. 177, f° 90r] or our transcription in [Beyhom, 2010c, v. 1, p. 504]):

”وأمّا الأوتار فأصلها أربعة وشدّ بعض المتقدمين وترًا خامسًا سمّاه الزير الحادّ“

("Concerning the strings: their number is originally four but some of the moderns tie a fifth string which they call the *zīr al-ḥād*").

The Western notation of the resulting degrees of the scale (we use mainly the Arabian solmisation) is based on the Pythagorean interval basis, which shows the difficulties for the use of such a notation on the *binṣir* or *wusṭā* line: in the Pythagorean system, flats and sharps lower or raise a note with the *apotome* (roughly equal to one *limma* + one *comma*, or 90c. + 24 c. = 114 c.). In the case of $B^{\#}$, $e^{\#}$, $a^{\#}$ and $d'^{\#}$ (and the hypothetical $g'^{\#}$) on the figure, a more "traditional" Western notation would have been *c* (or $c^{+}$), $f^{b}$, $b^{b}$ and $e^{b}$; however, if the corresponding pitches *c*, *f*, *b* and *e* were to be placed (logically) at 408 cents from the nut (with a Pythagorean ratio of 64/81), *c*, $f^{b}$, $b^{b}$ and $e^{b}$ would correspond to their unaltered counterparts minus one *apotome*, (roughly) 408 – 114 = 294 c. This is however not the case, and the $B^{\#}$, $e^{\#}$, $a^{\#}$ and $d'^{\#}$ notations reflect more faithfully the reality of the positioning, as adding an *apotome* to the *B*, *e*, *a* and *d'* pitches from the Pythagorean position at 204 cents (with an 8/9 ratio) would give an interval of 204 + 114 = 318 c. (to the cent) which is much closer to the 316 c. value corresponding to the ratio 5/6. Please note that I have also avoided using "Just Intonations" notations in the figure as this would have been introducing a bias upon Arabian music, notwithstanding the fact that this would be anachronistic.

69 The upper string's perfect fifth interval (from the nut) is divided into 16 equal parts ("quarters") and the second's string perfect fourth interval (also from the nut) is divided into 12 equal parts. This is equivalent to the division of the octave in 28 "quarters", or equal parts of the string and quarters of the intervals between the 12 equal parts division, which gives as a result the main degrees of the Arabian scale.

70 [Jairazbhoy, 1975, p. 44].

71 Available in languages that I could read.

72 Like many other musicians or scholars, my first reaction to the *śruti* system was to consider them as equal intervals: "It has been necessary to clarify the connection between the seven *svaras* and Bharata's two series of *śruti* values before proceeding to the examination of the nature of the *śrutis* themselves. Since Bharata distinguished twenty-two *śrutis* within one octave, it seemed self-evident that one *śruti* was equal to one twenty-second of an octave; this would mean that the octave was divided into twenty-two equal parts. This was the generally accepted conception until the beginning of the 20th century." – in [Kolinski, 1961, p. 4].

73 I present in [Beyhom, 2014] (forthcoming) a few propositions for a better understanding of the latter theories.

74 Mainly his article on Indian music [Coomaraswamy, 1917].

75 More precisely, for the latter, his article on the 22-*śruti* scale [Jairazbhoy, 1975] as his book [Jairazbhoy, 1971] deals mainly with "modern" Indian music.

76 And to the least beginning with the *śruti* scale found in Bharata-muni's treatise on music, as I further explain in the text.

77 A particularity of the Arabic language is that it has two different plurals: the dual, and the plural proper; two *mujannab*(s) should be termed *mujannab*[ayn], whenever more *mujannab*(s) (or *mujannabs*) would be transcribed *mujannabāt*: as transcription of the Arabic language is already a complicated matter, we use the undifferentiated *mujannab*(s) for ease of understanding for the reader.

78 The range of thank expands far beyond these few authors, but it would be too long to list them all here; please note also that a comprehensive and maybe helpful review on Indian music theories and their evolution can be found in [Powers and Widdess, 2001].

[79] Alain Daniélou was the champion of such explanations, notably in [Daniélou, 1968], in which he uses [see for example p. 32-36] Pythagorean ratios to explain his "66-*śrutis* scale"; the 66-*śrutis* scale is also (and already) present in [Daniélou, 1949, p. 50–56], not to mention [Daniélou, 1943] and [Daniélou, 1959] in which Pythagoreanism is omnipresent; A. H. Fox Strangways openly acknowledges in [Strangways, 1908, p. 30] that his "article seeks to establish some underlying principles for Hindu *rāga*, to trace the connection between the early music of Greece and of India", and deploys considerable efforts in his book on "Hindostani music" in order to express the sizes of the intervals in the scale in Pythagorean-like ratios. Despite his frequent references to Aristoxenus (see for example [Strangways, 1908, p. 464] and [1914, p. 103, 114, 125, 156 etc.]), the author's scale in his table [Strangways, 1965, p. 117 of the lithographic reprint of the 1914 edition] contains three different *śrutis* the sizes of which 22, 70 and 90 cents; the final construct carefully avoids any "neutral" tones in the scale. However, "[t]he crucial question […] is whether the system as a whole is based on the cyclic or on the divisive principle, to use the terms suggested by Sachs," (as put in [Kolinski, 1961, p. 4]), knowing that "[t]he divisive hypothesis assumes that 7 *śrutis* represented the major third 4:5 or 8:10, and that this interval has been divided into the major whole tone 8:9 of 4 *śrutis* and the minor whole tone 9:10 of 3 *śrutis*."– in [Kolinski, 1961, p. 5].

[80] "The number of the *Śrutis* in the *Ṣadja Grāma* are as follows: three in *Ṛṣabha* (*ri*), two in *Gāndhāra* (*ga*), four in *Madhyama* (*ma*), four in *Pañcama* (*pa*), three in *Dhaivata* (*dha*), two in the *Niṣāda* (*ni*) and four in the *Ṣadja* (*sa*)" – [Bharata, 1961, v. 1581, p. 6 (XXVIII.25.26 & XXVIII.27.28)]: this scale corresponds to ↑3 2 4 4 3 2 4 (in *śrutis*), a perfect conceptual match for the scale of *maqām Ḥusaynī* (ascending ↑3 3 4 4 3 3 4 in quartertones, with a *bayātī* + *rāst* ascending tetrachordal structure – or *bayātī* ↑3 3 4 + disjunctive tone 4 + *bayātī* ↑3 3 4) in Arabian music. By beginning on *sa* instead of *ri*, we obtain the ↑4 3 2 4 4 3 2 (in *śrutis*) scale. The author further states (same page) that the structure of the *Madhyama Grāma* is as follows: ↑4 3 4 2 4 3 2 (in *śrutis* and beginning with *ma*), which is a perfect conceptual match for the scale of *maqām Rāsd-a-dh-Dhīl* as shown in the figure below (taken from [Beyhom, 2003b, p. 56]), and for a few others *maqām*(s) (different names in different *maqām* regions).




[81] *i.e.* a scale using the so-called "neutral tones": the word "*zalzalian*" originates in the name of Manṣūr Zalzal, an 8th to 9th century *ʿūd* player at the *ʿAbbāsīd* court of Baghdad, reputed to be the first to use positions for "neutral thirds" on the fingerboard (see for example [Farmer, 2001]). The question whether "*zalzalism*" (or "*zalzality*") originated with this musician remains however highly controversial.

[82] In his book *The modal system of Arab and Persian music: A.D. 1250-1300* Wright explains how the Pythagorean positionings of the pitches in Urmawī's theory are to be considered *zalzalian*, *i.e.* based on intervals approximately equal to the 3-quarter or 5-quartertones used in Modern Arabian theories of the scale. Ṣafiyy-a-d-Dīn al-Urmawī even formulated in his second epistle on music (the *Risāla a-sh-Sharafiyya* – see [Urmawī (al-), 1982; 1938]) an explicit *zalzalian* third (which he calls "Persian" for reasons explicited in [Wright, 1978] and that I further explain in [Beyhom, 2010b] and in [Beyhom, 2014] – forthcoming) with the ratio *59/72* corresponding to 345 c. and an explicit *zalzalian* second with the ratio 59/64 corresponding to 141 c., as I have already reminded in a number of papers ([Beyhom, 2006a; 2007a; 2007e]). Both these *zalzalian* third and second are found on the neck by halving the string length corresponding to other intervals obtained through a Pythagorean construct, which shows that the equal division of the string is one of the ways used by the Arabs in order to include *zalzalian* intervals in a scale (see for example [Urmawī (al-) and Jurjānī (al-), 2001, v. 3, p. 110–120], with also useful information on the undifferentiated use of the *mujannabāt* for describing the tetrachords of Arabian music by Urmawī). I have also explained (in [Beyhom, 2010a]) how Ṣafiyy-a-d-Dīn's "Pythagorean" theory is, basically, an attempt to force *zalzalian* intervals in a Pythagorean costume – more details on Urmawī's *zalzalian* conception of the scale are to be found in [Beyhom, 2014] (forthcoming).

[83] For example, a 3 *śrutis* interval is always greater than a 2 *śrutis* interval in the course of, for example once again, one same melodic phrase. Proportionality is the rule, but the exact measures of the intervals may (and do) vary.

[84] "The *Vīnā* is tuned thus; the two lowest strings at the distance of a Fifth, the rest in Fourths. It has at present four fretted strings on the fingerboard and three unfretted at the side played as a drone by the (armed) little finger of the right hand." – in [Strangways, 1908, p. 454], and: "There is little doubt that the consonance of fourths and fifths was of fundamental importance in ancient Indian music" – in [Jairazbhoy, 1975, p. 42].

[85] (Ref. 6; p. 114) Here, Kolinski refers to [Strangways, 1914, p. 114]: "It appears from the table of *mūrchaṇas* that all the twenty-two *śrutis* except the first and twenty-first are accounted for. These two are inserted, by analogy, in the next diagram in square brackets as consonant notes from the eighth and tenth *śrutis* respectively."

[86] Here, Kolinski refers to [Daniélou, 1943, p. 121–122], in which the latter notably states (p. 122): "If we exclude from this series G+ (Pa+) (Abb), the fifth being invariable, we obtain a scale of twenty-two sounds, the *śrutis*"; Daniélou furthers compares [1943, p. 122–123] the 22-*śrutis* system to the "Arabian" and "Ancient Greek" scales: "This scale is identical to the one given by Arab mathematicians as having been that of the ancient Greeks, and it still remains the division used by the Arabs themselves. The major tone is thus divided into minor tone, apotome (or major half-tone) and limma"; this shows that Daniélou can hardly be considered as a supporter of the "divisive" theory, but should rather be considered as a promoter of the Pythagorean ("cyclic") system applied to the Indian scale.

[87] Kolinski refers here to [Clements, 1913, p. 101], in which the author concludes: "The fallacy underlying the theory of the equality of the *śrutis* is demonstrated by the numbers given. They are calculated on the basis that a one-*śruti* interval is 22 cents, two *śrutis* 112, three *śrutis* 182, and four *śrutis* 204. The 3 *śrutis* interval of the *Gandhara Grama* is 134 as explained in the text. It will be seen that the ancient system required 25 *śrutis*, and not 22, three of them being confounded with their neighbors".

[88] [Kolinski, 1961, p. 5]; Powers, in his review of Kolinski's article [1962], strongly criticises some major points of his reasoning and confirms ([Powers, 1962, p. 223]) that "Mr. Kolinski's basic premise is that the system of 22 *śrutis* must somehow or other be connected with the 'cyclic' method of tuning by fifths, rather than with the 'divisive' method based on just intonation". Please note that the only systematic homogenization of the transliteration of Indian musical terms (throughout the numerous citations in the article) was applied to the word *śruti*. Most of the other transliterations were left unchanged in order to reflect the time, but also the place of transliteration.

[89] [Coomaraswamy, 1917, p. 165].

[90] [Kolinski, 1961, p. 4–5].

[91] "[S]ince each of the twenty-two *śrutis* has its proper name, one should infer that each of these twenty-two names has its distinctive meaning. Does this, then, involve the assumption of a basic division of the octave into twenty-two tones? By no means. Both the general tonal

structure of Indian music and the nature of the quintal principle from which, as we saw, the 22-*śruti* complex must have originated converge into the concept of a system of twelve tones within the octave, that is, a collective chromatic scale into which all heptatonic and other Indian scales and modes may be projected if differentiations in intonation of secondary structural importance are not taken into account" – in [Kolinski, 1961, p. 6].

92 [Coomaraswamy, 1930].

93 As Jairazbhoy [Jairazbhoy, 1975, p. 54 – note n° 12] puts it: "Coomaraswamy (referring to [Coomaraswamy, 1930]), has argued, on the strength of textual descriptions, that the ancient Indian *vīnā* was a bow harp. This seems to be corroborated by early Indian bas-reliefs. Bake (referring to [Bake, 1957]) has, on the other hand, argued with some justification that Bharata's experiment only makes musical sense on a stopped stringed instrument". Another corollary assumption is that the *śruti* is not necessarily an equal size interval over the octave, as Popley [1921, p. 26] puts it: "The *śruti* or microtonal interval is a division of the semitone, but not necessarily an equal division" (although I do not really understand why the *śruti* should divide the semitone, and not the tone or the fourth as two other possible examples) – see also [Dick, Widdess, and Geekie, 2001], notably: " In South Asia, short-necked lutes first appear in the Graeco-Buddhist art of the 1st to 3rd centuries C.E. of Gandhāra. They appear in Buddhist art from the 2nd to 6th centuries C.E., and thereafter sporadically in Hindu art to the end of the millennium. They generally occur in the same contexts as harps". Let us note that the equality of the *śrutis* may also have been a hypothesis of Indian musicologists and researchers or musicians: "Um die europäischen Forscher mit der genauen Intervallgröβe der *Śrutis* bekannt zu machen, sandte Tagore 1886 an Ellis eine *Vīṇā*, auf der die vollständige 22-stufige Leiter durch feste Bünde fixiert war. Die Teilung der Oktave war in der Weise vorgenommen, daβ die Saiten-länge in zwei Hälften, die so entstehende untere Quarte in 9, die obere Quinte in 13 gleiche Teile zerlegt wurde. Ellis bestimmte die den Bünden der '*Śruti-Vīṇā*' entsprechenden Tonhöhen und berechnete, vom Grundton aus folgende Werte in Cents (Hundertstel des temperierten Halbtons): 0 45 111 169 222 267 316 389 436 505 534 583 640 712 […] 749 807 855 917 954 1013 1077 1136 1220 […] Ellis vermutet, daβ eine 22-stufige temperierte Leiter intendiert war" – in [Abraham and Hornbostel, 1904, p. 382].

94 To whom I am indebted for most of my practical knowledge on Middle-Eastern Arabian music today.

95 The different kinds of instruments, with different tunings.

96 In traditional non-standardised instrument making, the "same" two instruments can have differences, albeit sometimes small, in tunings, measurements etc.

97 On the fingerboard of a *ʿūd*, for example, thicker finger tips or smaller hands (or longer fingers) can change the way in which the musician performs, thus inserting additional (sometimes very small) discrepancies of intonation between the intervals used by two different musicians; such differences of intonation remain whatever the musical practice is, as long as the instruments themselves are not completely standardised and equally tempered. This, and other factors which contribute in introducing differences of intonation and heterophony into modal music are discussed in some of my writings, including [Beyhom, 2001; 2003a; 2003b; 2003d; 2004; 2007c; 2008; 2010a], and especially [Beyhom, 2007d].

98 Or for its transposed equivalents.

99 This is common knowledge for any educated musician or teacher (of Arabian traditional music) in the Middle-East.

100 The term "natural" should be considered with considerable caution here: this expression is, to the least in this article and in my other writings, used in a mere conventional way in order to indicate that the degree *e* conforms to the usual unaltered *e* in the Western scale.

101 (Reminder): Plural of *mujannab*, a term used in Ancient Arabian manuscripts to define the position of the finger, on the fingerboard of the *ʿūd*, for what was to be called "neutral tones" (*i.e.* tones that are neither "major" nor "minor" in Western music standard theory) by Western musicologists.

102 In the *Kitāb al-Adwār* – see one of the references [Urmawī (al-), 1980; 1984; 1986; 1938; 2001], and [Beyhom, 2010a].

103 Information about performance practice in Urmawī's writings is very scarce: all details on this subject are to be found in Owen Wright's magisterial book on the Systematists [Wright, 1978].

104 More detailed information about Urmawī's use of the *mujannabāt* is to be found in [Beyhom, 2010a], and in [Beyhom, 2014] (forthcoming).

105 This is the replica of Figure 5 in [Beyhom, 2010a].

106 [Urmawī (al-), 2001, p. 6].

107 Please note that in Urmawī's theory two consecutive *mujannab*(s) are never equal and have the form (L C + L L) or (L L + L C), the total of which is a "minor" third equal to one tone plus one *limma* (or 3L + C, as the tone value is L L C, or two *limmata* plus one *comma*, in combination). The reader may find detailed explanations on the different type of intervals used in Arabian music theories beginning with the 9th century and on the way they are used in these theories, especially in Urmawī's *Book of cycles*.

108 For Ancient Arabian music theories, see [Beyhom, 2010c]; for modern performance, this is a reality of today's teaching and of yesterday's (the turn of the 19th to the 20th century) music on old records (see [Beyhom, 2014], forthcoming).

109 Indian music specialists compare sometimes the "3 *śrutis*" interval to a "small", or "minor," tone, and the "2 *śrutis*" one to a "semitone" – see for example [Popley, 1921, p. 31], or [Bake, 1957, p. 61]: "Indian music recognizes two, three, and four-*śruti* tones which roughly correspond with our semi, minor, and major tones". The same author asserts: "As it was quite clear, even after the first attempt to translate Bharata's extremely concise text, that this *pramāṇa-śruti* was an interval equal to the difference between a major and a minor tone, investigators accustomed to the mathematical approach of the Greeks to their music, at once applied Greek standards to determine the measurement of the standard *śruti* (*comma* of Didymus) and from those premises began detailed calculations as to the exact measurement of the 22 *śrutis* which find a place within the compass of the Indian octave" – [Bake, 1957, *ibid.*].

110 [Kolinski, 1961, p. 3].

111 See [Beyhom, 2010c, *Appendix A*].

112 To the least in Arabian music, contemporary and Ancient: the (somewhat successful) attempts to depict ancient *ʿūd*(s) as "fretted" are mere attempts to impose a fixed temperament (often based on a Pythagorean division of the octave) to Ancient Arabian music – see [Beyhom, 2010c, *Appendix A*] and [Beyhom and Makhlouf, 2009], as well as [Beyhom, 2011].

113 Especially when these positions are determined by complex ratios such as the ones used for the Pythagorean *limma* and *comma*, for example.

114 This is an exact copy from [Subramanian, 1985, p. 12 – Fig. 8] previously used for the exposé on the origins of the *ʿūd* in [Beyhom, 2010c, v. 1, p. 304 – Fig. 105].

115 From [Marcel-Dubois, 1937, Fig. i]: by kind permission of Rosy Azar Beyhom who made the line drawing.

116 Please note that there is no origin issue here as the Ancient Indian treatises predate with no doubt the first Islamic treatises on music, as well as the *vīnā* predates (to our knowledge) the *ʿūd* – see for example [Jairazbhoy, 1972, p. 63]: "Musical theory in India stems from the *Nātyaśāstra*, ascribed to the author Bharata, which is generally dated from the second to the fifth century A.D.". As the first extant writings on Arabian music theory are the epistles of (al-) Kindī, the *Philosopher of the Arabs* (9th century), *mujannab* is only used conveniently as an interval which is well known in Arabian music theories.

117 Logarithmic computation is relatively modern though musicologists tend to forget about it. As a consequence many believe that "equality" can only be conceived in modern terms.

118 These numbers are rounded to the closest integer unit. Please note that, obviously, multiplying 55 cents by 22 *śrutis* will give us a value which is not a perfect match for the octave (exactly 1217,44 if using the accurate mean value of the *śrutis* – rounded to 1217 cents to an octave, which is 17 cents surplus); this is however no issue for an Ancient theorist because the octave is still divided in 22 equal *śrutis*, the ones used to divide the perfect fourth in 9.

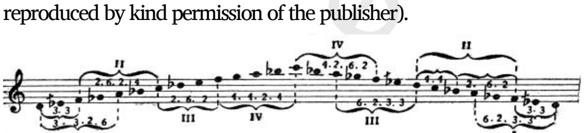
119 "The two main theories which find support are both based on sound musicological principles. The first of these, described by Fox Strangways, derives the *śrutis* from the 'divisive' principle where the tones are determined on the basis of simple fractions of string length. The second, described by Kolinski, derives the *śrutis* by the 'cyclic' or 'up and down' method in which the tones are determined by perfect fourths and fifths. […] Both theories arrive at the conclusion that the *śrutis* were of three different sizes; 22, 70 and 90 cents in the 'divisive' and 24, 66 and 90 cents in the 'cyclic'. The evidence in the *Nātyaśāstra*, however, seems to suggest that the *śrutis* were of one constant size, or at least, that they were thought to be so." – in [Jairazbhoy, 1975, p. 38].

120 Except for transpositions to the perfect fourth, due to the nature of the tuning and of the division (the first in perfect fourth and the second dividing this interval in equal parts). This can be easily checked on Figure 20.

121 It could however bear parallel marks indicating the theoretical positions of the *śruti* division, or other small marks playing the same role on the top of it.

122 As already explained above in the text.

123 The octave interval is not, for example, a necessary characteristic of the *maqām* scale, as some *maqām*(s), and specifically *maqām Ṣabā* of Arabian music for example, are constructed in such a way that they avoid the octave interval (in this case the ascending scale as can be seen on the figure below from [Erlanger, 1949, v. 5, p. 282 – Fig. 123], reproduced by kind permission of the publisher).



78— Echelle du Mode ṢABĀ

FIG. 123.

124 Let's also remember that the octave is not an interval resulting from the cycle of fifths cherished by most musicologists dealing with Indian music – see [Beyhom, 2010a ; 2010c, v. 1, p. 56–70].

125 Jairazbhoy's explanation on this subject ([Jairazbhoy, 1975, p. 54]) is noteworthy: "The total number of *śrutis* in the octave, twenty-two, is only incidental, being determined by the size of the unit of measure".

126 In [Beyhom, 2010a] as one example.

127 The same does not apply to the ratio between $M_2$ and $T$ expressed in cents and expressed in *śrutis*, as 2/3 (=0.67) and 3/4 (0.75) are nearly the same.

128 In the "3 2 1 3 2 1 3" division, the fourth's value would be 3+2+1=6 elementary intervals (*śrutis*?), which means that the *string's* division is on the basis of 24 division in all (the perfect fourth emplacement on the neck is at one fourth of the string and it contains 6 elementary intervals – this corresponds to a division of the string in 24 equal string-parts, and of the octave – from the nut to half of the string – in 12-equal string-parts).

129 As (24-3)/24=21/24=7/8. If we were to divide the half of the string in 15 (which is the sum of the elementary intervals in the "3 2 1 3 2 1 3" division), the ratio would be based on a division of the string in 30 equal-parts (15 for the octave between the nut and the half of the string, and 15 for the other half of the string), and the ratio of the first 3 elementary intervals (the "tone") would be 27/30, or 9/10. In other terms, the first result (7/8) is based on a tuning of the strings in fourths and the subsequent division of the length of the fourths in 6 equal string-parts, whenever the second result (9/10) is based on a division of half of the string in the 15 elementary intervals that would result as a whole from the "3 2 1 3 2 1 3" division. This is just another example of the numerous possible uses of the equal division of the string technique.

130 It is much easier to get to the 4/5 ratio than to the 29/36 ratio as the calculations are much simpler (and an eventual folding of the string even simpler); if it was to be used as such in the division of the string, however, this would have changed all the overall division in equal string-parts which I think is the basis of the *śruti* system.

131 Compare this discussion with: "Perhaps a musicologist could have determined empirically that tones of three different sizes were used in Samavedic chant. Further, he may have determined that the largest tone was about double the size of the smallest and the third tone was somewhere between these two in size. Since presumably he had no way of determining the size of this intermediate tone with any accuracy, nor an objective standard of intervallic measure against which to compare it, the obvious way would be to attempt to relate it to the other tones. In practice this is virtually impossible to do by ear alone and the most convenient approximation which suggests itself is to consider it as being half-way. Thus, if the smallest tone is expressed by the numeral one, the large tone would be two and the intermediate tone one and a half. Fractions are clumsy to handle and in this case would easily be eliminated by doubling each of these numbers. This would mean that the size of the small tone is now assigned the number, two; the intermediate tone, three; and the large tone, four. These are in fact, the *śruti* values of the tones given in the *Nātyaśāstra*" – [Jairazbhoy, 1975, p. 52]. Please note also that number 36 can be divided by a variety of smaller numbers like (1) 2, 3, 4, 6, 9, 12 and 16; this gives many possibilities for ratio simplifications, as we can see for example for the second, third and fourth *śrutis* on Figure 20 (with ratios 17/18, 11/12, 8/9, as well as the sixth, the eighth and the ninth (with ratios 5/6, 7/9 and 3/4).

132 As opposed to "quantitative".

133 With probably an exception in what concerns the perfect fourths and fifths; this is the case in most of the theories of modality, including *maqām* and Byzantine chant theories, as we show in [Beyhom, 2014] and [Beyhom, 2013] (forthcoming).

134 For example applying to this scheme the well-known experience of the two *vīnās* of Bharata Muni [Bharata, 1961, v. 1581, p. 7–9]: due to the impossibility to check by myself the original manuscripts (and language – these two conditions are, in my experience, very important because of the tendency of the commentators to interpret the manuscripts at their convenience), I simply can not know if this experience is compatible with the equal string-division of the fourth.

135 It seems however that the 28-quarters division of Shihāb-a-d-Dīn is superfluous as a conceptual construct, as only 14 or 17 degrees in

the general scale have names of their own; the further division in *Safinat al-Mulk* of the 14 *anṣāf* (or halves) found in previous theories seems to be a step towards more accuracy in the determination of interval sizes or degree positions, *i.e.* supplementary intermediate positions between the degrees used for small intonations or unusual transpositions. On the other hand, the fact that almost all the degrees (or the intermediate intervals between them) of the old Indian scale are accounted for (see [Strangways, 1914, p. 114]) seems to mean that the 22-*śruti* construct is conceptual in its essence (see [Beyhom, 2010a] for more details about *conceptual* and *measuring* theories and their differentiation), or "more" conceptual.

[136] "Apart from the tempered instruments of modern Europe there scarcely exists an absolutely fixed scale. [...] [T]he meaning of the *śruti* concept has to be discussed. Was it but a simple expedient to determine roughly the three different sizes of the *svaras* or did it involve an actual subdivision of the octave into twenty-two tones? The way in which Bharata utilizes the *śrutis* hints at the former interpretation" – in [Coomaraswamy, 1917, p. 165].

[137] Or aiming at fixing.

[138] The measurement of string and pipe lengths was conceivable since earliest times.

[139] See for example [Jairazbhoy, 2008] concerning this point.

[140] The $b^-$ and $e^-$ degrees could be here considered as *zalzalian* (and noted $b^{hf}$ and $e^{hf}$) if not for the discrepancy between the corresponding interval and its "standardised" *zalzalian* form (on Figure 20: 350 c. from the nut).